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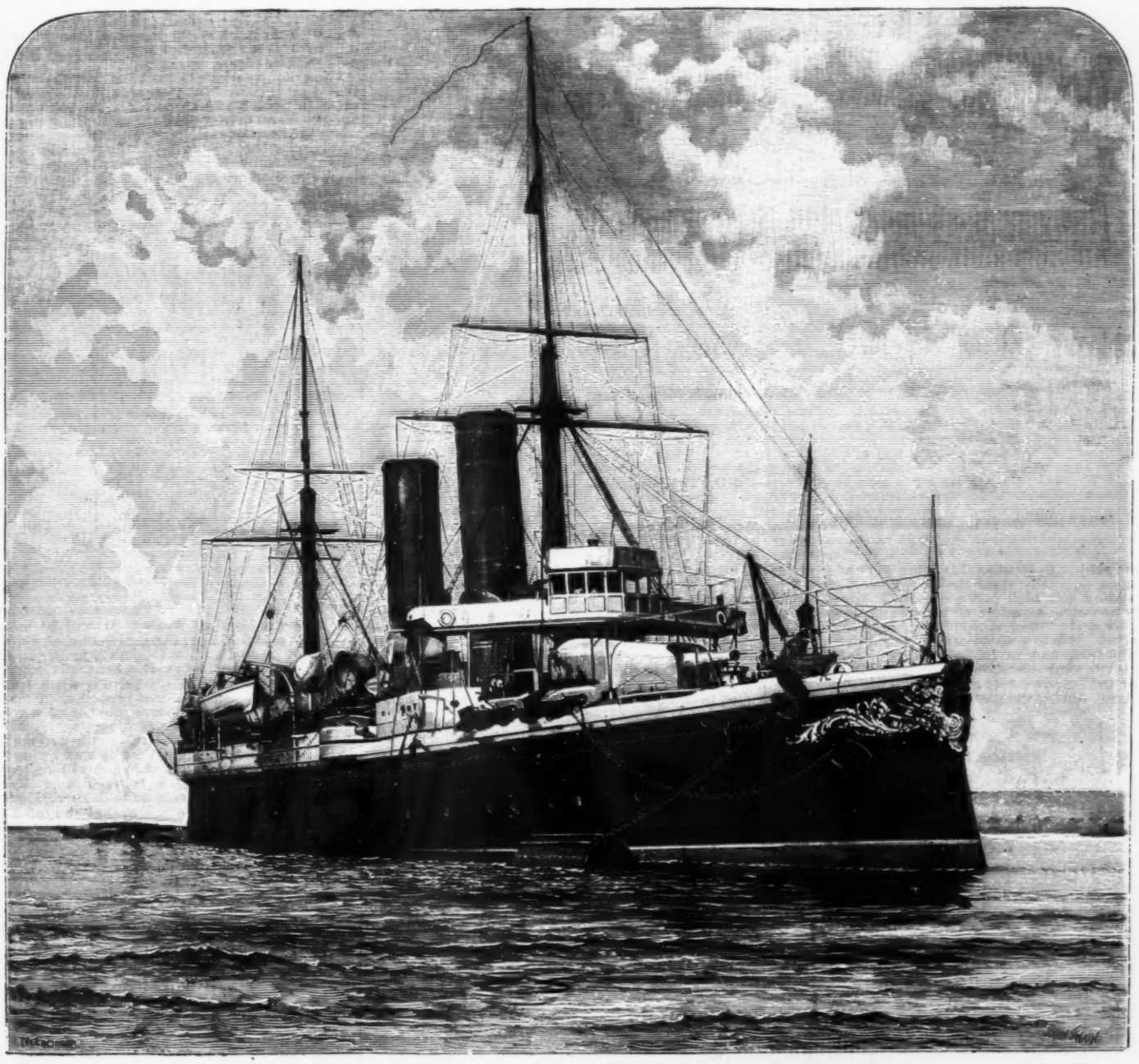
THE BRITISH WAR SHIP BLAKE.

THE Blake and the Blenheim are two new sister ships lately added to the British navy. They rank among the fastest and best of the modern cruisers. A description of one will answer equally well for the other. The power developed on the latest trial of the Blenheim was 14,900 horse power and the speed 20·4 knots. The Blake has not shown quite as much speed nor reached her full development of power, owing to imperfections of her thrust bearings and boilers. The Blake's intended power is 20,000 horse power. These vessels are of 9,000 tons displacement at 25 ft. 9 in. mean draught; length 375 ft. and beam 65 ft.; built at Chatham, and the armament consists of two 9·2 in. 22 ton breech-loading guns, ten 6 in. 5 ton guns and sixteen 3 pounder quick-firing, and eight machine guns, with torpedo-launching carriages and tubes. The propelling engines by Maudslay Sons & Field, Lambeth, consist of four distinct sets of triple expansion inverted cylinder engines, and occupy, with boilers, etc., nearly two-thirds of the length of the ship. They are placed in four separate compartments, two sets being coupled together on the starboard and port sides respectively for driving each screw. There are four high pressure cylinders, 36 in. in diameter; four intermediate cylinders, 52 in.; and four low pressure cylinders, 80 in.; with a stroke of 4 ft. Each set of engines has an air pump 33 in. in diameter and 2 ft. stroke, and a surface condenser having 12,800 tubes and an aggregate surface of 2,250 sq. ft., the length of the tubes between the tube plates being 9 ft. There is also in each compartment one centrifugal circulating pump driven by a small independent engine, of the diameter of 3 ft. 9 in., and capable of pumping from the bilge as well as the sea. The screw propellers are 18 ft. 3 in. in diameter with a mean pitch of 24 ft. 6 in.

Steam is furnished by six main double-ended boilers, having four furnaces at each end, and one auxiliary boiler, with a heating surface of 900 sq. ft., the dimensions of the former being 15 ft. 2 in. by 18 ft. and of the latter 10 ft. by 9 ft. long. The total area of fire grate surface is 863 sq. ft. and of heating surface 26,936 sq. ft. Each engine room is kept cool by four 4 ft. 6 in. fans. Forced draught is produced by twelve 5 ft. 6 in. fans, three being stationed in each stokehold. The electric lighting machinery consists of three dynamos of Siemens manufacture driven by a Willans engine, each of which is capable of producing a current of 400 amperes. The after main engines can be easily disconnected and worked separately for slow speeds.

The Blake, with both engines going full power ahead and turning to starboard, with her helm hard over 35°, completed the circle in 4 min. 40 sec., the port circle being completed in 5 min. 5 sec. The diameter was estimated approximately to be about 575 yards. Forty-five seconds were required to change from engine steering to steering by hand. By manual gear the helm was moved from midships to hard a-starboard in 40 sec., from starboard to hard a-port in 2 min. 10 sec., and from hard a-port to midships in 2 min. 20 sec. The heavy balanced rudder and the speed of the ship throwing great labor upon the crew manning the wheels, the hand gear was afterward disconnected and the connection with the steering engine completed in 40 sec.

There was a singular absence of vibration, said to be due to the space over which the machinery is spread, but perhaps also due, in part at least, to the number of cranks, as the cylinders deliver six throws throughout the circle of revolution.



THE BRITISH HIGH SPEED CRUISER BLAKE.

ON BALANCING MARINE ENGINES AND THE VIBRATION OF VESSELS.*

By A. F. YARROW.

ALL who are acquainted with the working of steamers provided with large power and of high speed, such as torpedo boats, torpedo boat catchers, and very fast passenger steamers, will be familiar with the fact that they are subject to considerable vibration under some conditions, especially since the adoption of steel for shipbuilding and high piston speed. To overcome it is daily becoming a matter of increasing importance, as higher and higher speeds are being continually demanded. It is to a study of the laws which govern this vibration, and to the possibility of avoiding it, that I invite your attention this evening.

I will first describe some experiments which we have carried out during the past few years, with a view to throw light upon the subject. At the outset we felt the want of some means of accurately indicating and recording the extent and character of vibrations, and therefore devised an instrument for the purpose. This instrument I have here this evening for your inspection. It has been in use for the last six years, and is, I believe, trustworthy. It consists, as will be seen, of a heavily weighted drum, suspended by elastic connections. This drum is provided with suitable clockwork to cause it to revolve, and is regulated to make one revolution per minute. Attached to an upright fixed to the stand of the machine is a pencil which presses lightly against the drum, round which a sheet of paper is wrapped, in the same manner as in an ordinary indicator. It will be readily understood that if the base of this instrument be placed upon a platform or the deck of a vessel subject to vertical vibration, this movement will be transmitted to the whole apparatus, excepting that portion which is suspended by the elastic connection, and this, being heavily weighted, will not follow the vibratory motion of the stand. Now, if we place our instrument on the stern or any part of a steamer which is vibrating, and start the drum revolving, the pencil, being pressed against the paper, makes a line, indicating the relative vertical positions of the pencil and the paper, or, in other words, makes a diagram which records the character and extent of the movement of that part of the ship upon which the instrument stands. This instrument we call a vibrometer, and it has mainly been devised by my friend, Mr. Nesbitt.

I believe the cause of vibrations in screw vessels, when running in smooth water with their propellers well immersed, to be mainly due to the forces produced by the unbalanced moving parts of the machinery, such as the pistons, piston rods, valves, gear, etc., excepting when it is the result of bad workmanship or bad state of repair. For example, as clearly pointed out by Mr. Barnaby, in his treatise on "Marine Propellers," vibration may be set up by a screw the center of gravity of which is out of the center line of the shaft, or it may be due to want of uniformity in the position, area, or shape of the blades. These causes being avoidable by proper care, I do not propose to deal with them. I would, however, take this opportunity to observe that sufficient attention is not always paid to these points.

Fig. 1

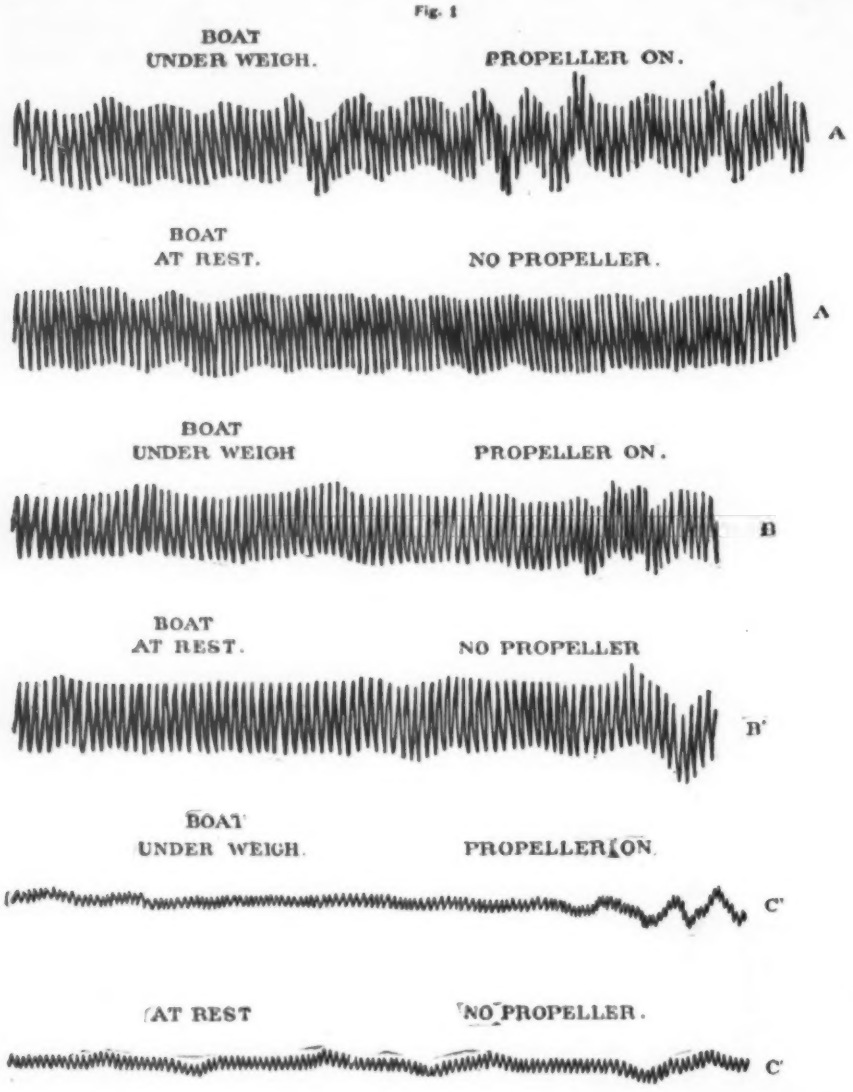
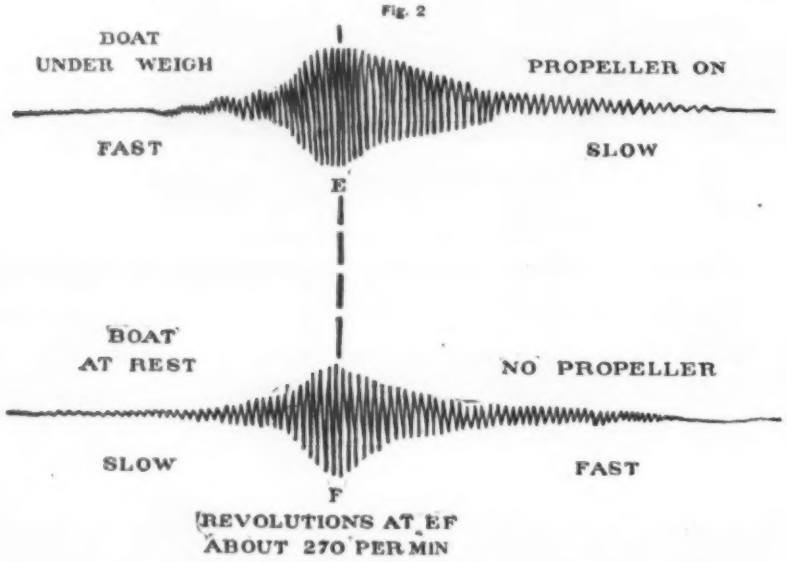


Fig. 2



From our experiments we have overwhelming proof that the vibration in a torpedo boat is precisely the same in extent and character when the screw is on, and the vessel driven by it through the water, as it is when the boat is stationary and the engines simply revolving without doing work, the propeller being removed. To prove that this statement is correct, I would beg your reference to Fig. 1, upon which are shown enlarged vibrometer diagrams, which have been obtained from torpedo boats when running and when stationary. These diagrams represent a fair average of over a hundred results. It will be seen that diagrams A and A¹ are practically alike, also diagrams B and B¹, and diagrams C and C¹, A, B, and C having been obtained when the boat was under way with propeller on, and A¹, B¹, and C¹ when the vessel was stationary, being without propeller. The engines were making exactly the same number of revolutions in each corresponding pair of diagrams. Not only do these diagrams prove that the screw had nothing to do with the vibration, and that it was owing to the working of the machinery, but it will be seen how greatly our investigation is facilitated by these facts, because experiments can be carried out with a boat at rest, and we know that the same results as regards vibration will be found under ordinary working conditions.

Fig. 3

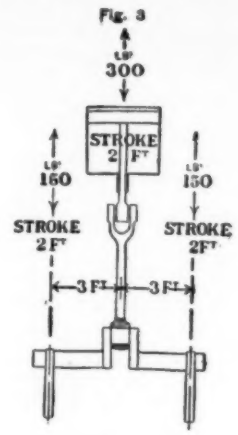


Fig. 4

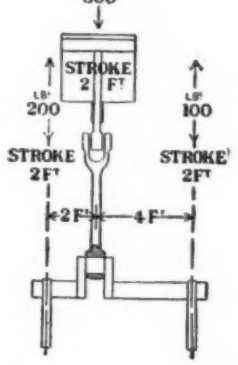
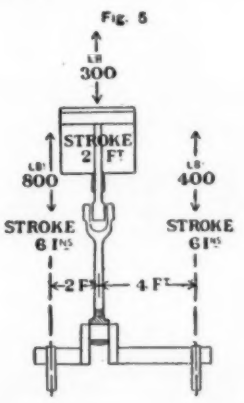


Fig. 5



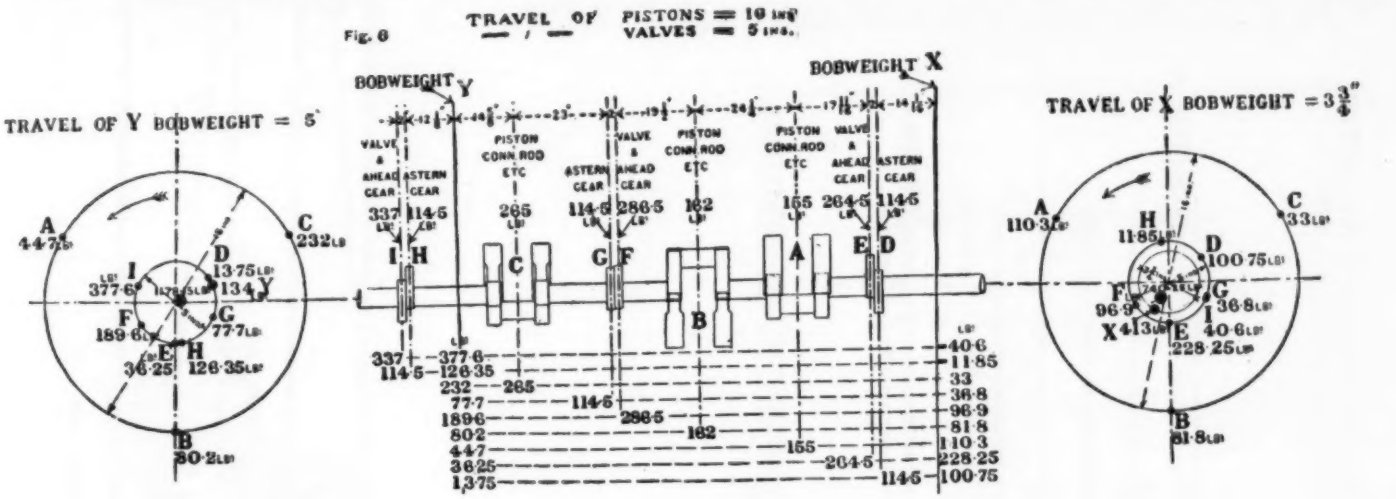
It is a well known fact that engines will impart their vibration to a boat at certain speeds much more readily than at other speeds, and it often happens that at full speed a boat may be practically steady, while at a slower speed the vibration is excessive. This is dependent upon the extent to which the movements of the reciprocating parts of the engine correspond with the period of vibration of the hull, which may be considered in this investigation as an elastic body. This is illustrated by the well known fact that when sol-

* A paper recently read before the Institution of Naval Architects, London, for which, with the accompanying illustrations, we are indebted to *The Engineer*.

diers are crossing a suspension bridge, it is often found necessary to avoid their marching in step. Some years since we had a boat in which severe vibration occurred at 200, 400, 600, and 800 revolutions per minute, but there was none at the intermediate speeds of 300, 500, and 700. The diagrams on Fig. 2 show very clearly how the vibration varies at different speeds, and the variation that takes place in the extent of the vibration when passing from one speed to another.

In a vessel such as a fast Atlantic liner, which is intended to run continuously at a nearly uniform speed —unless special means be taken to balance the machinery—it is of the utmost importance to carefully avoid the number of revolutions of the engines per minute keeping time with or, in other words, synchronizing with the normal vibration of the hull. This cannot be carried out in the case of war ships and others which are intended to run at varying speeds; for if the speed of the engines be proportioned so as not to set up vibration at full speed, they will probably do so at intermediate or cruising speeds; and if they set up no vibration at cruising speeds, they will probably vibrate at full speed. I believe it would be by no means a difficult matter to determine in the original design, with fair accuracy, what speed of engine would be suitable to avoid vibration being set up in any given design of hull. We frequently hear of propellers being changed in order to reduce vibration, and in many cases the change is made with advantage; but it often happens that the improvement is not directly due to the altered shape of the propeller, but indirectly to the change causing an alteration in the number of revolutions of the engines, and thereby preventing them synchronizing with the natural vibrations of the ship. We hear of hulls being strengthened or built stronger than would otherwise be necessary, with a view to reduce vibration. Doubtless this is done with more or less success, due, possibly, not so much to the greater strength of the hull, but rather to the period of vibration being modified by this stiffening, so as to avoid its harmonizing with the movements of the machinery. Building vessels of greater strength than would otherwise be necessary, with the object of avoiding vibration, cannot be considered a scientific method of dealing with the difficulty, if it can be proved that vibration can be avoided by other means and without

Fig. 6



but it clearly adds considerably to the wear and tear of the vessel.

Let us consider exactly why an engine produces vibration. In an ordinary inverted engine the steam presses on the cylinder cover and on the piston, and from the piston the stress is transmitted to the bed plate. Now, during the first half of the down stroke the upward pressure on the cylinder cover is greater than the downward pressure on the bed plate to the extent of what is needed to set the reciprocating parts in motion, and this excess of upward over downward pressure lifts the engine bed and that portion of the hull to which it is attached. By a like train of reasoning it can be shown that during the latter half of the down stroke and the first half of the up stroke the tendency is to lower the engine bed; also that during the second half of the up stroke the tendency is to raise the engine bed. To sum this up in a few words, during the upper half of the revolution the engine tends to lift the vessel, and during the lower half to depress it. The main principle which governs the whole matter may be thus summed up: As no internal force can move the center of gravity of a body, it follows that any momentum generated by steam pressure in the moving parts, such as the piston, etc., must be attended by an exactly equal momentum in the rest of the ship in the opposite direction.

We will now pass on to consider how to design engines so that they may be perfectly free from vibration. For this purpose please refer to Fig. 3, representing a single cylinder inverted engine, which for

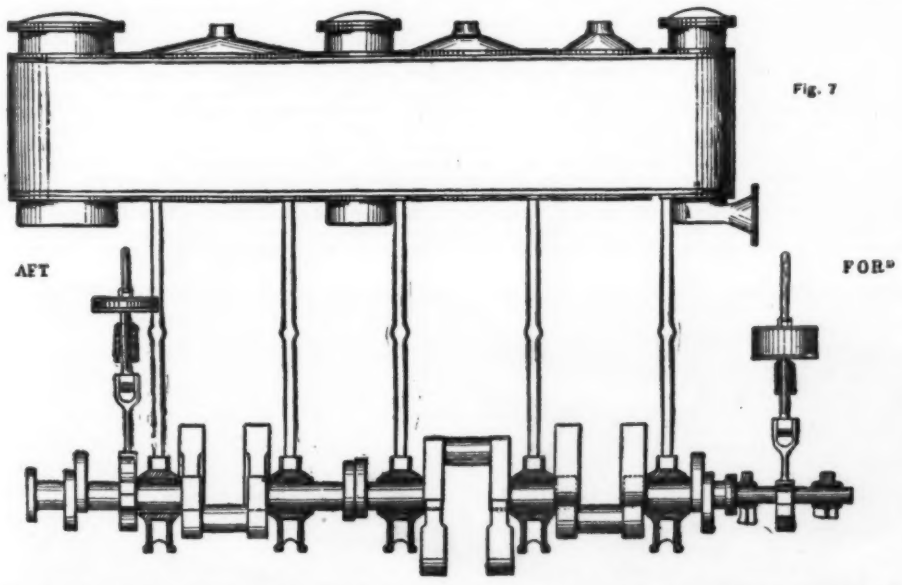


Fig. 7

extra weight, because extra weight of material added to the ship tends to handicap its speed. The true cause of vibration being due to machinery, I think it will be admitted that the correct mode of dealing with it is to so design the engines that they may be steady within themselves and free from any tendency to cause the hull to vibrate. As a further proof that the vibration is due to the machinery, I may mention that two years ago I made a passage to the United States in one of the very fast twin-screw steamers. I selected a berth in the central portion of the vessel, thinking it a good position for comfort, but the vibration was found to be so excessive that after five days it was scarcely bearable to those passengers whose berths, like my own, were situated at the points of greatest vibration. The vibration was found to vary periodically. When the

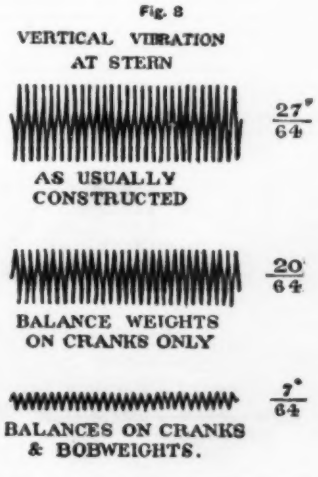
the sake of simplicity we will assume has no valve gear. The revolving parts, such as the crank, crank pin, and a portion of the connecting rod, can be balanced by means of rotary weights in the usual way, and we then have only the vertical, unbalanced parts, such as the piston, piston rod, etc., left to deal with. Now, if we have two eccentrics set opposite to the crank, at equal distances from it, and of equal stroke to it, and these impart an up-and-down motion to weights, which we will call "bob weights," each of which is half as heavy as the parts to be balanced, that piece of mechanism will revolve free from vibration, excepting that which is due to the angle of the connecting rods. If we wish to place these weights at unequal distances from the crank—see Fig. 4—they must be proportioned to vary in weight inversely as their distances from the crank, that is, if one weight be twice as far from the center of the crank as the other, it will have to be half the weight of the other, the sum of the weights in this case being the same irrespective of their position. If we desire to reduce the stroke of these weights so as to obtain a convenient length of stroke—see Fig. 5—we shall then have to increase their weight inversely as the stroke, that is, if we quarter the stroke the weight will have to be quadrupled, and so forth. It will thus be seen to be a simple matter to proportion the bob weights, their stroke, and their position, to suit what may best work in with any design of engine.

To sum up in a few words what must be done to avoid the effect of the momentum generated by the working parts being felt by the hull, an equal momentum in an opposite direction should be produced. If, instead of using bob weights, rotary weights of equal amount had been employed, having their centers of gravity in the same position as the centers of the eccentrics, which give motion to the bob weights, the engine would still be balanced vertically, but would be unbalanced horizontally.

I would now direct your attention to Fig. 6, showing the calculation as applied to triple-expansion, vertical engines. The most suitable positions are first determined for fixing the two eccentrics which give motion to the bob weights, in this case the one lettered X being at the forward end of the engines, and the other lettered Y being between the low-pressure crank and its valve eccentrics. Each unbalanced moving part in the engine is then dealt with separately, as before described, and the position and amount of the weights necessary to balance it ascertained, the stroke of the balance weights being taken, for the purposes of calculation, as equal to the stroke of the part they balance in each case. For instance, take the middle-pressure piston, piston rod, etc., lettered B, the unbalanced reciprocating parts of which weigh 162 lb., the balance required at X is found to be 81·8 lb., and at Y 80·2 lb., the stroke of each being 16 in. Taking another instance, for example the high-pressure valve and its go-ahead gear, lettered E, weighing 264·5 lb., the balance at X is found to be 228·25 lb., and at Y 36·25 lb., the stroke of each being 5 in.

After dealing in a similar manner with all the reciprocating parts, if we were to construct two uniform disks with each of the weights thus found pinned on in its proper relative position, and place them respectively at X and Y, the engine would be balanced vertically. All the weights at X might be replaced by one large weight equal to the sum of them, and having the same position of center of gravity; in a like manner the

Fig. 8

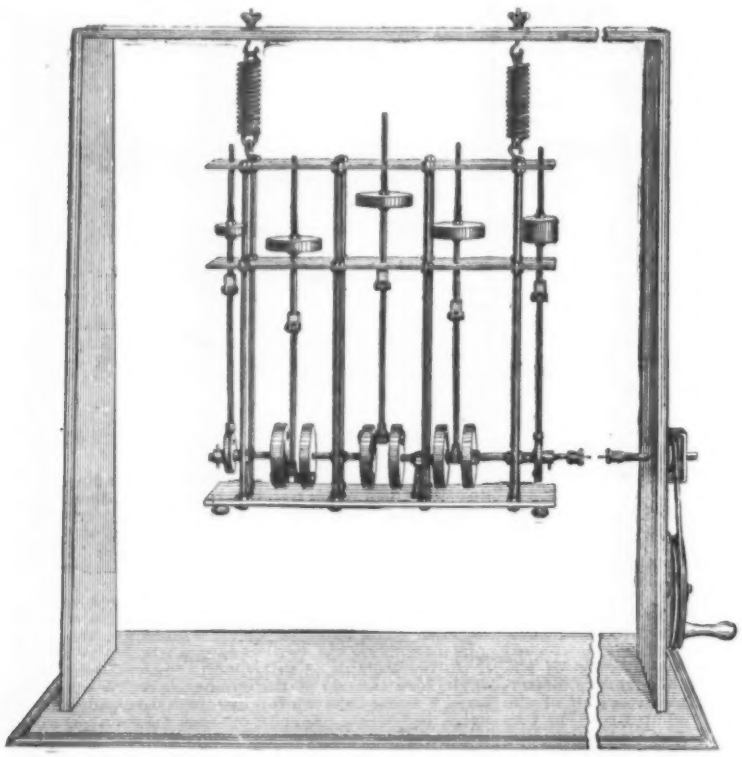


weights of Y may be dealt with. These are shown by the large black spots on the diagrams. These, again, might be substituted by larger or smaller weights as convenient, situated nearer or further from the center of the shaft, the amount of the weight being in the inverse ratio to the distance from the center. It will be seen that in the present case the total weight of all the balances equaled 740·25 lb. at X, and 1,178·15 lb. at Y, and the distance of their center of gravity from center of shaft was 1·04 in. and 0·28 in. respectively; these would be equivalent to a rotary weight of 413 lb. at X, with its center of gravity 1⅓ in. from the center of the shaft, and a rotary weight of 134 lb. at Y, with its center of gravity 2½ in. from the center of the shaft; these two weights would balance the engine vertically, but would set up side vibration. To avoid the latter and

retain only the vertical effect, the use of bob weights equal to the rotary weights and having the same vertical motion and in the same relative position on the shaft are substituted. This method was adopted in the engines we shall refer to later on.

The correctness of this mode of calculation is confirmed by experience in practical working. The exact amount, position, and stroke of the bob weights can be accurately calculated in the original design, and if they be made accordingly, no vibrations will take place at any speed. The calculations are simple, but care must be taken that they are based on accurate data. To estimate the weights of the reciprocating parts from drawings is not sufficient; they should be ascertained by actually weighing the finished articles.

Triple-expansion engines with three cranks, although partially balanced when at rest, are very far from balanced when at work, owing to the distance between



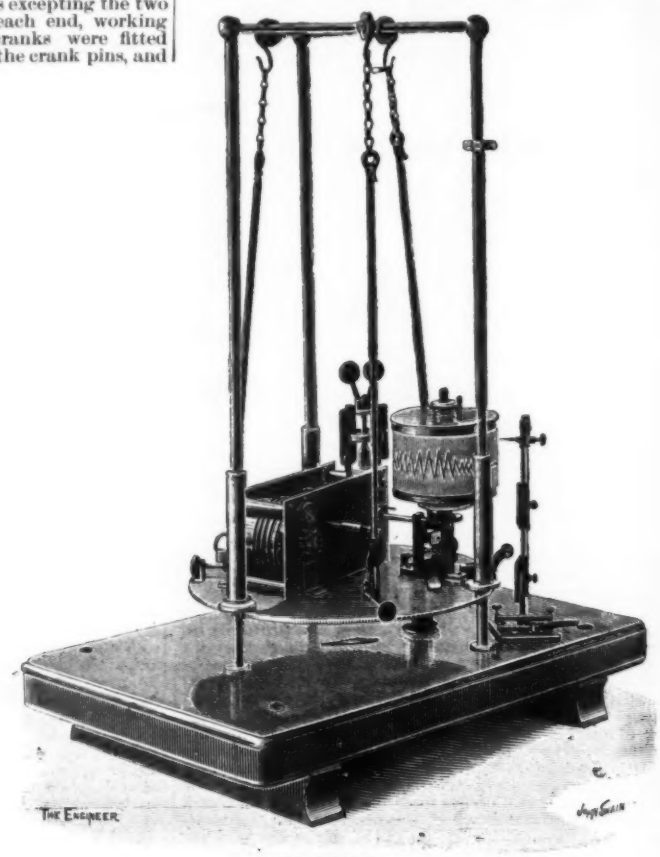
MODEL ILLUSTRATING THE VIBRATION OF TRIPLE-EXPANSION ENGINES.

the various reciprocating parts, which consequently set up a rocking motion, which is the principal one to be overcome, and in such engines this rocking motion we have to deal with in addition to the vertical motion of the center of gravity, this vertical motion being due to the difference in weight of the working parts of the three engines. The positions of the bob weights should be chosen so as to minimize their weight. What weight may be necessary to avoid vertical vibration of the center of gravity is constant, but what may be required to avoid rocking motion is diminished by an increased distance apart of the weights. In double-cylinder engines with the cranks at right angles it is a more pronounced galloping motion, *i. e.*, a motion of a complex kind, being a compound of vertical motions of their center of gravity and a rocking motion.

In a single-cylinder engine the vibration of the engine is practically up and down; but with whatever type of motion we have to deal, the same principle of balancing holds good. All forces causing vertical vibration can be neutralized by the use of bob weights, arranged to set up equal forces acting in an opposite direction. Some years ago we thought the vibration in triple-expansion engines was due to the difference in weight of the pistons, and with a view to balance them and, as we supposed, avoid vibration, we made each piston of the same weight in a first-class torpedo boat; thus we prevented any vertical movements of the center of gravity of the engines, yet we found no improvement. This clearly indicates that the rocking vibrations are of more importance than the vertical vibrations in triple-expansion engines.

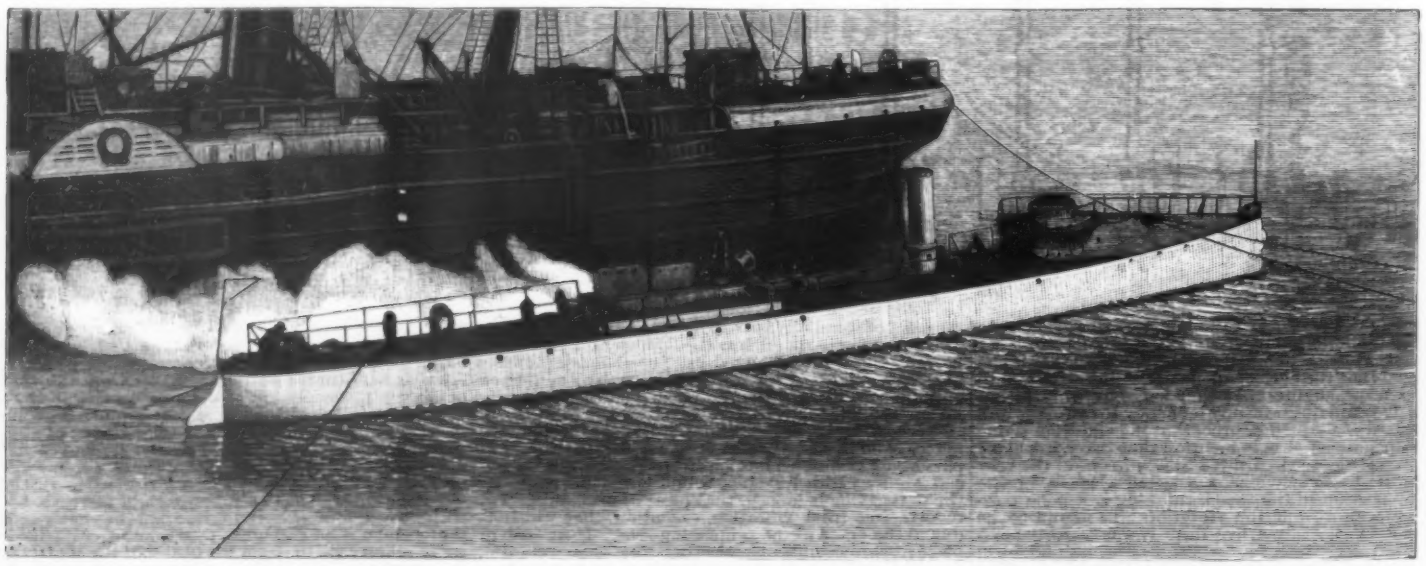
There is one feature about the vibration of vessels which deserves attention, viz., that it varies in intensity at different points in the length of the hull; there are places where it is excessive, and places, termed nodes, where it does not exist. I will now refer you to Fig. 7, showing some engines indicating about 1,100 horse power for a first-class torpedo boat, 130 ft. in length by 13 ft. 6 in. beam, having a speed of from 22 knots to 23 knots, carrying a load of 20 tons. There is nothing special about the engines excepting the two eccentrics fixed on the shaft at each end, working vertical bob weights. To the cranks were fitted weights sufficient to balance them, the crank pins, and partially the connecting rods. How far each connecting rod was balanced by rotary weights was determined by its weight and the lateral movement of its center of gravity; what remained unbalanced was balanced by the bob weights worked by the eccentrics, their stroke and weight being calculated as already explained when describing Fig. 6. Experiments were made with this boat in the Thames and also in the West India Dock. We tried her under three conditions—(1) Without any balance weights whatever, as engines are usually constructed; (2) with balance weights on the cranks only; and (3) with balance weights on the cranks and bob weights. The amount of vertical vibration at the stern as obtained in the river is given on Fig. 8, together with enlarged vibrometer diagrams, from which it will be seen that the results corresponding to the three conditions show a vibration of $\frac{33}{64}$ in. as usually made, $\frac{10}{64}$ in. with balance weights on crank, and $\frac{1}{64}$ in. with balances on cranks and bob weights. I have not the slightest doubt, from more recent experience, that this small vibration that remained could still further be reduced, and in fact practically avoided altogether, by taking greater care in accurately ascertaining the weight of all moving parts. The foregoing trials were all made at 248 revolutions per minute, which corresponded in this boat to the speed producing maximum vibration, that is to say, when the movement of the engine synchronized to the greatest extent with that of the boat. I believe that the vibration of the largest Atlantic liner can in this way be practically overcome by the expenditure of a few hundred pounds, if carried out in the original design. Bob weights proportioned and arranged as already described may be reduced in amount if wished, being substituted by a rotary balance weight equal to such reduction; this, however, must not be carried out to an extent to produce sensible side vibration.

Thinking it would be of interest to the meeting, and in confirmation of the statements put before you, I propose to throw on the screen a series of instantaneous photographs, taken while our experiments were being carried on. In all cases the revolutions were 248 per minute, and it is the ripples on the water produced by the vibration of the boat to which I would direct your attention. One of these gives a broadside view without balance weights, from which not only can the disturbance of the water in the immediate vicinity of the boat be seen, due to its vibration, but the points where the vibration is the greatest, and the position of the nodes where there is no vibration.



VIBROMETER

To further illustrate the system and prove its correctness, I have here a model corresponding to a triple-expansion engine; the weights of the pistons have been similarly proportioned to one another, as in our torpedo boat engines. It will be seen that the shaft is made to revolve by a flexible wire, so as to avoid the result being vitiated by the mode adopted for causing it to revolve. This model engine is suspended by springs in order to be quite free to move vertically. You will notice when we set it going that unmistakable vibration is at once set up. The rotary weights, such as crank, crank pin, and lower ends of connecting rods, are all carefully balanced by balanced disks, and consequently this vibration is due entirely to the vertical moving parts. We will now



VIBRATIONS PRODUCED BY THE MACHINERY OF STEAM VESSELS.

connect the bob weights on each side, the amount, stroke, and position of which have been arrived at by a similar calculation to that already described. The effect of these bob weights in completely avoiding the vibration will be clearly seen.

In conclusion, I would desire to thank those members of my staff who have been occupied with me in carrying out these experiments—Mr. Crohn, Mr. Nesbitt, and Mr. Marriner—for the able way in which they have assisted me in the investigation I have had the honor of laying before you this evening, which I hope you will consider of interest.

CONCRETE IN HARBOR WORKS.

THE property of developing great adhesive and cohesive strength under water, which Portland cement possesses in such a remarkable degree, even when submerged while in a plastic condition, was utilized early in the history of that material, and has permitted the foundations of sea, river, and dock walls, breakwaters, etc., to be laid under water without either coffer dams or the costly operation of pumping. Although there are great advantages connected with the use of concrete blocks for under-water work, there can be no doubt that freshly made plastic concrete has been successfully used for the same purpose, even in situations where it is exposed to the disturbing effects produced by waves and tidal or other currents.

The harbor works at Newhaven, on the coast of Sussex, present an excellent example of the extensive use of plastic unset concrete, or as it is frequently called concrete *in situ*, this material having been almost exclusively used in the construction of that massive breakwater and other works at that port.

The breakwater has at present a total length of about 1,500 ft., terminating in a depth of about 15 ft. below L.W.S.T.; the top of the breakwater has a width of 30 ft., is 10 ft. above high water, and is surmounted by a covered way and parapet running along the outer side, both sides battering 1 in 8 (see vol. xl., page 1).

The breakwater, which in a W.S.W. direction is unsheltered from the force of the Atlantic, is founded on the rough natural sea bottom, and the foundation course has a width of 50 ft.; the lower portion of the structure, from the bottom up to a level of 2 ft. above low water, consists of 100 ton sacks of concrete deposited while plastic; the canvas with which the concrete was enveloped was of jute, weighing about 27 oz. to the sq. yd. The sacks were dropped into place by a specially designed steam hopper barge having a well 42 ft. long, 6 ft. deep, and about 8 ft. wide. The sack blocks in the finished work became flattened to a thickness of about 2 ft. 6 in.

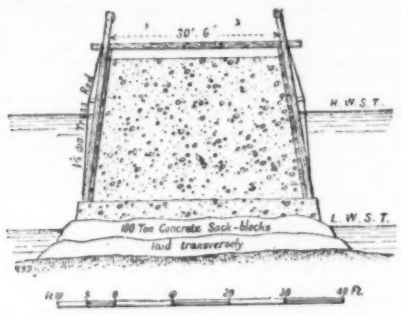
With the exception of this sack work the breakwater is built of plastic concrete laid *in situ*. The profile framing was formed of half balk timber trussed with 1¼ in. round iron rods (see annexed figure) spaced 5 ft. apart along each face of the breakwater, and secured at the bottom in wrought iron sockets and at the top with timber crossheads 12 in. by 6 in. The sheeting consisted of 3 in. planks planed on the inside and jointed. It was found economical to build the breakwater in working lengths of 40 ft. At Newhaven spring tides rise 20 ft. and neap about 15 ft. The concrete used in the construction of the breakwater was generally one part cement to seven of shingle and sand, but in fine weather concrete of one to nine was used in the hearting and on the sheltered side.

The sectional area of the breakwater, including the covered way and parapet, is about 50 sq. yds., and its construction occupied five years—from 1880 to 1885. The average rate of progress would therefore be about 15,000 cub. yds. per annum. The average cost of the concrete in the breakwater was 22s. 4d. per cub. yd. The sand and shingle for the concrete were obtained from the adjoining foreshore. Summarizing for convenience of comparison, we obtain the following results:

Quantity of concrete deposited in place per year..... 15,000 cub. yds.
Total cost of concrete work..... *M.* 2s. 4d. per cub. yd.

In addition to the breakwater, concrete *in situ* was also used at Newhaven in the construction of two extensive sea walls and a quay wall 900 ft. in length. This material has therefore been more extensively used in these works than in any others of a similar character, and its power to resist the physical and chemical action of the sea will be a matter of great interest in harbor engineering.

At Blyth, on the coast of Northumberland, plastic concrete was used in the construction of a quay wall 712 ft. in length and founded at a depth of 15 ft. below low water. The plastic concrete was deposited under



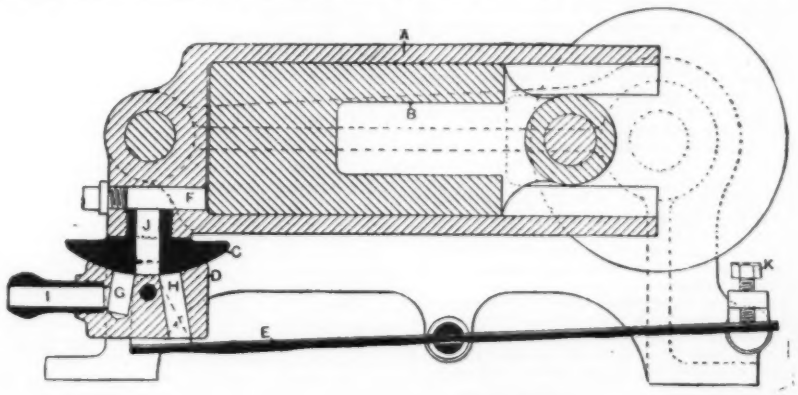
water in the usual manner, that is with a hopper-bottomed box, which in this case had a capacity of 16 cub. ft. A diver was also employed who directed the lowering of the concrete, and afterward trod it into place.

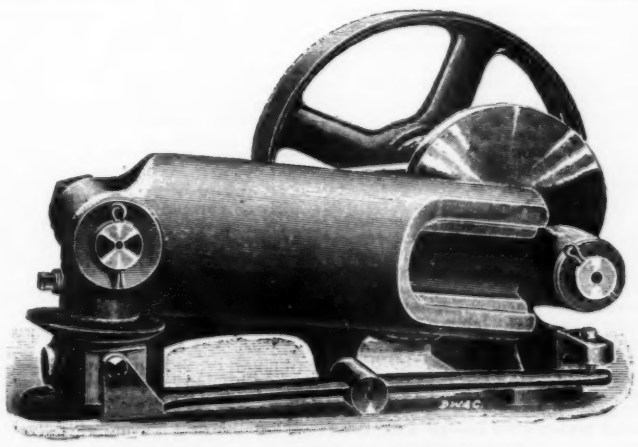
The concrete below low water consisted of six parts of broken stone and sand to one part cement, by measure. Above that level the proportion was seven to one, and in addition large stones were worked into the concrete. The net average cost of the concrete was 15s. 9d. per cub. yd., which does not include plant, this latter item costing 1,276*l*. The addition to be made to this account would amount probably to about 2s. per cub. yd. The stone and sand required for the concrete were obtained from ballast brought to the port by ships.—*Engineering.*

IMPROVED AIR COMPRESSOR.

WE give below a novel and simple arrangement of air compressor, which is by Tyler & Ellis, Crown Court, Cheapside, London. The special feature of the compressor is the arrangement of a spherical valve, attached beneath the oscillating cylinder in such a way that the movement of the cylinder itself automatically opens and closes the air passages at the right periods.

As will be seen from the sectional illustration, the cylinder, A, is pivoted on a strong pin at the rear, secured to the frame, the piston, B, being attached to the crank disk, I, by a trunk arrangement. To the lower side of the cylinder is attached the spherical valve, C, having a passage, J, communicating through F with the cylinder, and making connection with H or G—the inlet and delivery passages—according to the position of the cylinder, and thence of the plunger in its stroke. The seat, D, is forced against the face of the spherical valve by means of a spring, the pressure of which can be easily regulated. The valve being spherical, it is constantly grinding itself true on its seat, while the spring which holds the seat against the face of the valve acts as a safety valve, since, when the pressure becomes too great, the valve is forced off its seat, and the air escapes. The compressor may be driven by means of a pulley and belt, and its extreme simplicity and fewness of working parts will, we doubt not, commend it to all who have occasion to use such machines.—*Practical Engineer.*





IMPROVED AIR COMPRESSOR.

GAMBIER AND ITS MANUFACTURE.

THERE are probably but few commercial products having such an extensive use as gambier or terra japonica about which so little is actually known, says *Industries*, regarding its origin and mode of preparation, and about the manufacture of which so crude a system prevails, and so few modern improvements have been introduced.

Cutch, catechu, gambier, and terra japonica are names that are attributed indiscriminately to two similar products—namely, that obtained by boiling the wood of *Acacia catechu*, a big leguminous tree of Burmah (where a large proportion of the substance is made), and evaporating the extract to a proper consistency, and that obtained by boiling the leaves and twigs of *Uncaria gambier*, which is the substance now under consideration. The first is properly called cutch, while the second is catechu, gambier, or terra japonica. *Uncaria gambier*, the plant from which this valuable tanning substance is obtained, is a native of the East, and is found either wild or cultivated in Malacca, Penang, and Singapore, as well as in Java and Sumatra. The plant belongs to the natural order *Rubiaceæ*, to which belong the cinchonas, or quinine-yielding plants, as well as the coffee. It is a strong shrubby climber. The flowers are small, closely crowded together in globular heads or receptacles. A very singular arrangement is to be seen in the peduncles, or flower stalks, for, after the flowers have fallen off, the lower portions become elongated; they also become very hard and woody, and curve into strong hooks, by which means the plant climbs. As an illustration of the utility of these hooks for climbing purposes, and the provision of nature in supplying them, they are sometimes produced without bearing any flowers.

Of the early history of gambier we may quote the following from Fluckiger and Hanbury's *Pharmacographia:* "That gambier was unknown to Europeans long after the time of Rumphius—who resided in Amboyna during the second half of the seventeenth century—is evident. Stevens, a merchant of Bombay, in his *Compleat Guide to the East India Trade*, published in 1766, quotes the prices of goods at Malacca, but makes no allusion to gambier. . . . The first account of gambier known to us was communicated to the Batavian Society of Arts and Sciences in 1780, by a Dutch trader named Couperus. This person narrates how the plant was introduced into Malacca from Pontjan in 1758, and how gambier is made from its leaves, and names several sorts of the drug and their prices. In 1807, a description of the drug called *Gutta gambier*, and of the tree from which it is made, was presented to the Linnean Society of London. The writer, William Hunter, well known for scientific observations in connection with India, states that the substance is made chiefly at Malacca, Siak, and Rhio, that it is in the form of small squares or little round cakes, almost perfectly white, and that the finer sorts are used for chewing with betel leaf in the same manner as catechu, while the coarser are shipped to Batavia and China for use in tanning and dyeing."

It seems that gambier plantations in Singapore were first commenced in 1819, and at one time there were as many as 800 plantations. These, however, continued to decrease down to 1866, in consequence of the scarcity of fuel and the high cost of labor. As the supply of gambier to the English market continued to diminish, the price, of course, rose, and what at one time cost £10 per ton was selling, it is said, at £45 for the same quantity. Consequently, the cultivation of the plant has rapidly increased.

Ordinary commercial gambier is an earthy-looking substance usually seen in somewhat irregular cubes about an inch square, dark brown on the outside, but of a reddish or yellow ocher color within. These cubes are often seen more or less compacted together by pressure into large lumps. By far the largest proportion of the gambier imported here is used in tanning and dyeing, but the finer and more carefully prepared qualities form a valuable astringent medicine, and it is much used in diarrhœa, dysentery, relaxed throats, etc. It will be seen from the following notes, taken from a reprinted article in the *Tropical Agriculturist* for February 1, 1888, that the whole system of manufacture of gambier is still conducted in the crudest fashion, and the illustrations will further show this fact. The writer states that the main points in gambier planting which are so attractive to Chinamen are the great rapidity with which they get a crop out of the ground and the small original outlay which is required. The history of the majority of these plantations will show that pepper has been planted out of gambier profits. Of course, pepper is a great "hit" when all goes well, but it wants a considerable capital to start with, and it takes some years before it gets into anything like full bearing. The leaf of the young gambier plant is thick and fleshy, and yields a large quantity of extract, but as the shrub ages the leaves become thinner and more fibrous in texture, and lose their characteristic fleshiness. In a little over ten years a plantation is almost valueless, and, as a general rule, is abandoned within fifteen years. This result is certainly due to the savage treatment to which the shrub is subjected. The Chinaman commences cropping his gambier about eighteen months after he has put it into the ground, after which he will go on cropping it two, three, or even four times a year, being guided more by financial considerations or market rates than by the fitness of his plantation for cropping. The shrubs are cut down with no sparing hand; leaves, shoots, and twigs are all lopped off, and the plant is almost reduced to the condition of a mopstick, and left with barely sufficient leafage to enable it to carry on its existence. No attempt is made to manure the plantation. It is quite an error to suppose that the plant exhausts the soil like indigo. The spent leaves from the gambier pans are said to be very good for pepper. They are, however, quite exhausted by the time they leave the pans, and cannot give any nourishment to the soil, but they form a useful shade and protection for the roots. For

the manufacture of gambier, the green leaves and shoots are roughly chopped from the plants with a knife called a "parang." The larger knife is used for chopping up the leaves and twigs before putting them in the boiler. The large basket is used for conveying the freshly cut plant from the plantations to the boilers or "qualli," while the smaller basket is employed for removing the spent leaves to the pepper or gambier plantations for manure. In the boiler, or qualli, the furnace is below, being of the roughest possible description, consuming an immense quantity of firewood. While the leaves are boiling they are incessantly prodded and twisted about by a heavy wooden instrument with five prongs, cut from a solid piece of timber. The wielding of this instrument is said to be the heaviest work in connection with the gambier manufacture. A sort of strainer is used made of a cocoanut shell. This is fixed on to a kind of sieve by the handle, so that it hangs down in the gambier liquid while still boiling, and after the larger debris has been removed by the coarse strainer. When the water in the boiler becomes thick or sirupy, the leaves are removed by the fork and placed in the sloping wooden trough, so that the liquor drains back into the boiler from the steaming mass of leaves. The liquor in the boiler is then ladled into small, shallow wooden tubs, and the leaves in the trough are once more swept into the pan and reboiled, after which they are carried off to the pepper plantations. The liquor left in the boiler from the second boiling is too weak to be converted into gambier, but is a good extract in which to boil the next lot of green leaves.

When the extract in the tubs has becomes sufficiently cool to allow the hand being placed in it, it is stirred or rather churned by a coolie, who sits before the tub and with a cylindrical piece of soft wood shaped like a baton incessantly works it up and down, the immediate effect of which is to cause the gambier to thicken, and in so doing to set up a kind of crystallization. When it is quite cool it is turned out of the tub and cut into cubes by a rough knife made from a piece of iron hooping. The cubes are next put on coarse bamboo trays and sometimes exposed to the air for a time, or the trays are placed in roughly formed racks in the factory, where they get smoke-dried, and in the course of five or six days have thrown off so much moisture that they are considerably reduced in size. The cubes are afterward packed in mats for exportation. Good sound gambier should be found in distinct cubes, externally of a brownish-black color, and of a deep mahogany red, with an occasional streak of dark yellow internally. Gambier varies, however, very much in quality, some of it being simply rubbish and some very much adulterated. Nevertheless it is a valuable commercial product, and with extended cultivation of the plant in the British colonies, and the introduction of machinery in its manufacture, its commercial importance might be very considerably enhanced.

RED LEAD.

RED lead is a quite important pigment now, and promises to be more so. Architects and engineers and all interested in structural iron work have almost unanimously decided that pure lead is the proper first coat for iron, and it is now being generally specified. It is the very best known preservative that can be applied in the shape of paint. Red lead will saponify oil very quickly, and therefore it must be freshly prepared for use. Many mix the dry lead with oil as they use it, but this is not satisfactory, nor will the small hand mill of the shop grind it satisfactorily, though it is better to run it through such a mill than not to grind it at all. Engineers almost unanimously insist on the use of the pure article. Recently a large order was prepared under specification of half red lead and half whiting.

I do not think this is a good mixture for the purpose; certainly the body is badly sacrificed, and not over one-fourth the quantity of red lead, the real preservative, would be applied to the surface as when the pure article is used, and such a specification would largely defeat the purpose of the use of red lead. Over this priming coat any color may be applied. One of the most useful second coats for preservative purposes would be a mixture, say of equal parts by weight, of red lead and a good iron oxide paint, such as a well-prepared metallic brown. Over this second coat any finishing color could safely be applied. If such work scales, it will be only in those places which were not thoroughly cleaned of rust before painting.

When a painter has a large job to do with red lead, he should have it ground for him by the manufacturer in such quantity as he would use up in two or three days; it should be well ground in a thin paste, say about 20 lb. oil to every 100 lb. red lead. This plan is now followed by contractors for painting large iron structures.

THE PREPARATION OF RED PIGMENTS FROM SLAG.

THE use of basic Bessemer slags for manuring purposes has long been known, but the slags from puddling and reheating furnaces have hitherto, on account of their composition, only found use as a low-priced ore. Mr. A. Sahlin has described a method, in a paper recently published by himself, by which these low-class slags may be utilized as paint stock, and their value greatly increased. The chief difficulty lies in reducing the slags to a sufficiently fine state of division. This end is accomplished, however, by the joint aid of the Blake crusher and the Cyclone pulverizer. As the result of this treatment about forty per cent. of the slag is obtained in a state in which it can be directly worked up as a pigment with linseed oil. The remaining sixty per cent. of coarser ore still remains to be dealt with, however. This portion is found to be capable of being converted into a pigment suitable for producing the dark shades of red paint, such as used by various railway companies for preserving rolling stock.

To effect this conversion the following method is adopted: 1,000 lb. of the ground slag, having a fineness of about 225 mesh, are mixed with from 170 to 200 lb. of 66° B. sulphuric acid acid (sp. gr., 1·83). The quantity of acid is governed by the shade desired in the finished product. The mixing is done first by hand and then in a chaser mill. When thoroughly mixed the slag is put away in a bin to "sweat." The chemical reaction is manifested by a rise in temperature to from 240° to 250° Fah.

The slag consists mainly of silicate of protoxide of iron, and the sulphuric acid naturally expels the weaker silicic acid, forming a sulphate of protoxide of iron. If roasted with admission of air, this sulphate is dissociated into free sesquioxide of iron and sulphurous acid, which latter is drawn off.

The sweating occupies about four days, and is accompanied by the escape of steam and a greenish discoloration of the slag. When reaction ceases, 500 lb. of the mass are charged into each retort of a calcining furnace. This furnace is fired with crude oil, air for combustion being supplied under pressure by a Baker blower. The retorts are heated to cherry red, and the slag while roasting is agitated so as to bring it in contact with the air necessary for rapid oxidation. At the end of from three to four hours the heavy dark slag has changed into a light, flaky, red mass, that is somewhat pasty. When the litmus paper test shows that the acid is entirely evaporated, the slag is cooled down and passed through a Cyclone pulverizer. The only difference in the grinding is that the whole product is now reduced fine enough for the highest grade of paint, thus leaving no second residue. The pulverizer reduces about 800 pounds of calcined slag per hour producing an excellent paint stock, varying in its depth of shade at the will of the operator, according to the amount of sulphuric acid employed in the preliminary treatment.

WHAT ELECTRICITY IS: ILLUSTRATED BY SOME NEW EXPERIMENTS.*

By W. W. JACQUES.

ELECTRICITY is, to all of us, more or less surrounded with an atmosphere of mystery.

When we speak of light, or sound, or heat, we feel that we are dealing with familiar things—things so familiar to our everyday life that it seems useless to try to define or describe them. Every day the sunlight fills all space; it dazzles our eyes; it falls upon the objects around us, and makes them visible; and though through the evening, when the sun is gone, we substitute for a while a gas flame, or a candle, or an electric light, we have then through the day had so much of it that at night we are glad to be rid of it, and have darkness for our hours of repose.

So, too, from babyhood to old age, all day long and every day, we are listening to one or another sound, whether the voices of friends, or the busy hum of city life, or the delights of music, or the ticking of the clock at night. Indeed, so constantly are our ears filled with sounds, that, when we go alone on to a high mountain, or a desert plain, where there are no trees to rustle with the wind, the silence is painful and oppressive and awful.

Heat, too, is equally familiar, perhaps even more so: for what is more familiar than the warmth of sunshine? And is not the fireside the very center, as well as emblem, of our home?

When, however, we speak of that other great force of nature, *electricity*, we feel that we are departing from familiar ground. It is shrouded in mystery; it is something we cannot see, or hear, or feel—something we cannot easily describe or define. We speak of it in the same breath with spirits and with ghosts. The reason, I take it, is because the human body has no organ especially adapted to recognize electrical phenomena. While the eye receives the ray of light, the ear the ray of sound, and any part of the surface of the body feels the heat, the presence of electricity cannot be detected by any of our senses. Electricity cannot be seen, or heard, or felt; it is tasteless and odorless.

Subjectively considered, then, electricity eludes our grasp.

Objectively, however, electricity is as familiar to us as light, or sound, or heat. Its phenomena have been as carefully studied and its laws are as accurately known.

Let us for a moment recall the physical explanation of light and sound. Let us picture to the eye of the imagination the mechanics of a ray of light.

When we stand out of doors on a cloudless night and look above us, we see a multitude of stars. The telescope tells us that some of these are suns, some are moons, and some are other worlds than ours.

The nearest of them is distant millions of miles, and yet we can see them. There is a chain of something linking the star at which we are gazing to the eye. This chain we call, familiarly, a ray of light. Physicists tell us that along the pathway from the star to our eyes there are chasing each other with enormous speed a multitude of waves of light.

If we turn our eyes to another star, it too sends to our eyes its waves of light. If we go to a distant part of the earth, the same stars send rays of light to us there. And so we find that each of the multitude of stars is radiating ceaselessly in all directions multitudes of waves of light.

Between us and the stars, and between the stars extending everywhere through visible space, is the medium that transmits these waves, crossed and intercrossed continually with countless waves of light—a medium rarer than the rarest gas—the medium that is still left in space when we remove from it all solids and liquids and gases, *the ether*.

Objectively considered, then, light is a wave motion of the ether that everywhere surrounds us and fills all space. By a similar wave motion, but in a coarser medium, the air, sound is transmitted from place to place.

By means of his vocal organs, a public speaker moulds the current of air that issues from his lungs into waves of sound. These waves of sound are radiated in all directions, and fall upon the various listeners' ears.

Something analogous takes place when we drop a pebble on to the surface of a placid lake. From this center of disturbance, waves of water are radiated in all directions until they reach the shore. Waves are likewise radiated downward to the bottom of the lake, and fishes have organs, like our ears, that enable them to take cognizance of these vibrations.

In the case of waves of water, or waves of sound, or waves of light, we know there is no bodily transference of a particle of water, or air, or ether, from the center of disturbance to the shore, or ear, or eye. Each particle moves at the most only through a minute fraction of an inch; but each pushes the next, and this the next, so that motion, and not matter, is what is transmitted to a distance. Indeed, this propagation of motion, in contradistinction to propagation of matter, is the essential characteristic of wave motion.

Who has not seen a wave pass over a field of grain? Each particle bows its head but for a few inches, yet the wave passes on to the utmost limit of the field.

Sound, then, is a wave motion transmitted through the air. Light is a wave motion transmitted through the ether. But both of these media are also capable of having set up in them currents in which there is an actual bodily transference of the medium from place to place through considerable distance.

In the case of air, we call this motion the wind. In the case of the ether, I propose to show that it is a current of electricity.

As wind is the bodily forward motion of the medium whose vibratory motion we call sound, so a current of electricity is the bodily forward motion of the medium whose vibratory motion we call light.

A current of electricity is a breeze of light.

We may, perhaps, best get a realistic conception of electric currents, whether flowing through open space or confined to a specially provided metallic conducting path, by first picturing to ourselves the phenomena of air currents, with which we are more familiar, and then mentally transferring these phenomena from the air to the more subtile medium, the ether. The analogies are very striking, and will materially aid the imagination in picturing electrical phenomena.

In the islands of the Pacific Ocean there is almost always a breeze, either from the land to the water or from the water to the land. In the daytime the island is heated by the sun, its air is rarefied and rises, and the cooler breeze rushes in from the ocean to take its place. At night the island cools, the air descends, and an outward breeze is produced. There is always a breeze from an area where the air is condensed and toward an area where it is rarefied. This local condensation and rarefaction of the air are the cause of breezes and winds and hurricanes. The maps issued by our weather bureau show areas of high and areas of low barometer, and the direction of the wind is always from the one to the other.

If, instead of allowing the wind to blow freely through space, we confine it to a narrow channel—if, for instance, we produce an air pressure at one end of a long iron pipe, we get through the pipe a strong current of air, as, for example, in pneumatic tubes, in which the current of air carries along small carriages, in the tin pipes used to convey the hot air currents from our furnaces to the registers, and in the pipes used for distributing illuminating gas from the central gasometer to the houses about the city where it is burned.

The wind blowing through space is made evident to our eyes by its scattering of a handful of dry leaves, or dust, or bits of paper. It bows and bends the branches of the trees. A candle flame exposed to it is distorted or instantly blown out. Its direction is more accurately indicated by the familiar weather vane, and its strength is measured, if we will, by the anemometer.

As with the wind of nature, so too with the electric wind. If we substitute for our Pacific island a metal ball suspended in mid-air by a silken cord, and let the ocean be represented by the surrounding atmosphere on a moist day, and produce upon the ball an area of *electric* condensation, or, as an electrician would say, a positive electric change, we shall have an electric breeze blowing outward in all directions, which will last so long as the electrification of the ball is above that of the surrounding air. This may be made evident to the eye by placing upon the ball a handful of bits of paper, or dry leaves, or dust, any of which will be instantly blown away and dissipated in all directions. If a lighted candle be brought near the ball, its flame will be bent by the breeze, and possibly be blown out.

If, instead of allowing this electric wind to blow away in all directions, we confine it to a narrow path—if, for instance, we connect the ball to the earth by a metallic wire—we get through the wire a strong current of electricity, whose direction may be determined by the electric weather wave, a magnetic needle, and whose strength may be measured, not with the anemometer, but by the galvanometer.

We may conceive of this electric wind as a breeze of the ether; the proof of the identity will be given later.

It is in currents flowing along metallic wires that the phenomena of electricity have been most carefully studied, and it is the phenomena of such currents that have therefore been for the most part utilized in electrical inventions.

Nature's wind is used to waft our ships across the seas, and it is perhaps not a wild idea to conceive of electric repulsion utilized to support and propel heavily laden air ships through the space above our heads; but it is with electric phenomena as they have been investigated and utilized up to the present time that we have to deal in this article, and this, as we have seen, means the phenomena of electric currents flowing through metallic wires.

What are some of these phenomena?

Electricity—or what we shall soon see is the same thing, a current of ether—passes readily through a copper wire. To the ether current, the wire is hollow; in electrical terms, it is a good conductor. It also passes quite readily through an iron wire, but not so readily as through copper. It passes still less readily through a wire of carbon. It passes more readily through a large wire than through a small wire. In all wires, there is more or less ethereal friction or electric resistance.

In virtue of this ethereal friction or electric resistance, the current heats the wire through which it passes—of course heating a small wire more than a large one, and heating an iron wire more than one of copper, and a carbon wire most of all. We see this in our household system of electric lighting. The current passes from the central station and throughout our houses to the lamps, over comparatively large wires of copper, which it warms only slightly; but coming to the lamps, it passes through a fine wire of carbon, in which the friction and consequent heating is so great

* An address before the American Academy of Arts and Sciences, Boston, 1892.

that the filament becomes white hot; and were it not contained in a glass globe, from which the air has been removed, it would take fire and disappear.

Again, an electric current flowing in a wire coiled around a bar of iron converts the bar of iron into a magnet, so that it may attract an iron armature placed near its end, and thus do mechanical work. The converse of this is equally true, and if we move an iron armature to or from the end of an iron bar around which a wire is coiled, an electric current will be set up in the same coil, and by means of the connecting wires may be carried to a distance and utilized. On this latter principle depends the dynamo machine, which furnishes electricity to be used for light or power. On the former depends the electric motor that propels our street cars, and furnishes power to many of our industries.

Again, the electric current flows through wires with enormous velocity, and consequently it offers an excellent vehicle for the rapid communication of intelligence—for telegraphy. A telegraph wire between two cities is merely a path through which the current may readily flow. At one end is a reservoir of electricity. The "key" is a device by which electricity may be allowed to flow into the line. By allowing small quantities of electricity to flow into the line at intervals of time in accordance with a prearranged code, and noting at their distant end their arrival, we may communicate any ideas that are capable of being expressed in such a code.

The arrival of these little currents of ether may be manifested to the eye in various ways. In the so-called needle telegraph, the current passing by a magnetic needle causes it to point in a given direction, just as the wind passing a weather vane causes it to point in a given direction.

If it were possible to have on one hill top a reservoir of air under pressure, or wind, and a key by which small puffs of air could be let out at intervals in accordance with a prearranged code, and on a neighboring hill a weather vane, we might thus have a wind telegraph operated exactly as is the electric telegraph. But such a telegraph would be slow and cumbersome in operation, and is not likely to come into general use.

There is one other phenomenon on which I desire to dwell a moment—a phenomenon of great importance, as it furnishes the first proof of the identity of electricity and the ether.

Suppose we have an ordinary telegraph wire in which there is a steady current flowing. Suppose, 10 ft. away from this wire, and entirely disconnected from it, we arrange a short wire with any suitable means of detecting an electric current in it, should such a current exist. So long as the current in the first wire flows steadily on, there will be no current in the secondary wire. If, however, the current in the first wire be broken up into rapid pulsations, say 100 per second, by rapidly opening and closing the circuit, we shall find in the secondary wire short pulsating currents occurring with the same frequency. How does this action take place? How are the impulses transmitted across apparently unoccupied space? The only conductor between them is possibly the moist air; but the same phenomenon takes place if the air be dry, or even if it be entirely removed. The only remaining explanation is that the pulsations are carried from one wire to the other by means of the intervening ether which we know fills all space. We shall see in a moment that the pulsations are transmitted by means of a wave motion of the ether from the one wire to the other.

Meanwhile, let us look at the analogy of this phenomenon as it takes place in a current of air.

Suppose we have a pipe in which there is a steady current of air flowing. Suppose 10 ft. away we place our ear. So long as the current of air flows steadily on, no sound will be heard. If, however, the current in the pipe be broken up into rapid pulsations, say 100 per second, by rapidly opening and closing its end, which may be done by means of a reed such as is used in organs, the pipe will radiate in all directions waves of musical sound of a pitch due to 100 vibrations per second, and this sound will of course be heard by the ear. In this case we have a current of air, by rapid interruptions, converted into waves in the air, or sound.

Analogy indicates that, in the former case, we had a current of ether (or electricity), by rapid interruptions, converted into waves in the ether (or electrical waves). But we must have stronger proof than the indications of analogy, and it is readily fortheoming.

If the interrupted current in the wire radiates ether waves, these ether waves are really nothing more nor less than waves of light. Unfortunately the eye only detects waves of light that are a small fraction of an inch in length, while the waves radiated from the most rapidly interrupted electric current are many inches in length. Nevertheless, the complete identity of waves radiated from an interrupted electric current and from a source of light has been confirmed by the study and identification of many of their phenomena, first by Maxwell, and later by Hertz; the most striking proof being that waves radiated from an electric wire are propagated through space with a velocity of 300,000,000 meters per second, which is the same as the velocity of light.

So far as wave motions are concerned, therefore, those radiated from an electric wire are just as much ether waves as those radiated from the sun, or any other source of light.

It remains now to show the identity of the electric current and a current of ether. For this I invite your attention to some experiments of my own, that seem to me to go far toward establishing this identity.

If we can find somewhere in nature a breeze of ether blowing with the necessarily enormous velocity freely through space, and show that it exhibits both qualitatively and quantitatively the same properties as an electric current, the simplest possible supposition that we can make is that they are identical.

Now, the earth in its daily journey round the sun rushes through the ether that fills all space with enormous velocity, and to the observer on the surface of the earth this is the same thing as if the earth were at rest and the ether flowed by with this same velocity. Just as the observer on the deck of a swift steamship at sea feels the same breeze, whether the ship moves forward with a speed of twenty miles an hour through a calm atmosphere, or the breeze blows with a velocity of twenty miles an hour by the steamship when at anchor.

Now, our problem is to detect and measure this ether breeze, and show that qualitatively and quantitatively it possesses the properties of a current of electricity. This I have done in the following way.

Before us stands a very sensitive balance, capable of detecting a variation in weight of one part in a million. I have replaced the scale pans with thin disks of brass, ten centimeters in diameter. Above and below each disk, and supported from the floor of the balance by glass legs, are other similar disks of brass. The two suspended disks are, of course, free to move up and down, but remain at rest so long as the equilibrium of the balance is undisturbed.

The remaining four disks are rigidly fixed, excepting as each can be raised or lowered by a delicate micrometer screw. For convenience I will designate the right hand disks *Rt*, *Rm*, and *Rb*, indicating respectively right hand top, right hand middle, and right hand bottom. Similiarly, I will designate the left hand disks *Lt*, *Lm*, and *Lb*. By means of a suitable battery I may electrify any of these plates, either positively or negatively.

Suppose, now, I electrify the beam of the balance, and consequently plates *Rm* and *Lm* positively. If the distances between plates are in all cases the same, the index will remain at rest. If it deflects, we know the distances are somewhere unequal, and must be adjusted by means of the micrometer, until there is no deflection.

If, now, I electrify *Rt* negatively, it will attract and lift *Rm*, and the index will move to the right.

If, however, I at the same time electrify *Lb* positively, it will tend to repel and lift *Lm*, and, as the repulsive lifting of *Lm* is equal to the attractive lifting of *Rm*, the index will remain at rest. That is, an *attraction* between *Rt* and *Rm* is balanced by a *repulsion* between *Lb* and *Lm*.

If, now, I suddenly change the electrification of the beam of the balance, and consequently of the plates *Rm* and *Lm*, to negative, we have a *repulsion* between *Rt* and *Rm*, balanced by an *attraction* between *Lb* and *Lm*.

Now, it can be shown by purely mathematical reasoning from electric phenomena (see Maxwell's Electricity and Magnetism, Chap. XIX.) that an ether current flowing between two positively electrified plates would, provided it possessed the electro-magnetic properties of a current of electricity, diminish their repulsion. If it flowed with the velocity of light, and had quantitatively, as well as qualitatively, the electro-magnetic properties of a current of electricity, it would just *neutralize* the repulsion.

If, on the other hand, it passed between two plates, one of which was charged positively and the other negatively, it would just double their attraction.

If, instead of moving with the velocity of light, 300,000,000 meters per second, it moved only $\frac{1}{10000}$ as fast, or 30,000 meters per second, the repulsion between similarly electrified plates would be diminished by one part in ten thousand and the attraction between oppositely electrified plates increased one part in ten thousand.

Now, it can be further shown from purely astronomical measurements that our balance is, on the 22d of December at noon, carried through space with a velocity of 30,000 meters per second.

Obsrvations made at noon on that day, then, ought to show the index of the balance one side of the position of equilibrium when the movable plates are electrified positively and the other side when electrified negatively. The difference should indicate a total change of force of one part in twenty-five hundred.

This deflection of $\frac{1}{2500}$ is that due simply to the rotation of the earth around the sun. That due to the rotation of the earth about its axis is too small to note. But the whole solar system is moving toward Hercules with a velocity of 8,000 meters per second.

On the 22d of March this velocity would have to be added to the velocity of the earth in its orbit, and on the 21st of September subtracted. On the 22d of December it would have no effect. Our deflection on March 22, then, should be about $\frac{1}{2000}$; on December 22, $\frac{1}{3000}$; and on September 21, $\frac{1}{2000}$.

Of course, in actually taking observations, it is necessary to use all six of the plates variously grouped and variously electrified, in order to get rid of accidental phenomena.

Even then the accidental phenomena frequently mask that for which we are searching, and it is only from the discussion of a considerable series of observations that results of value are obtained.

I began my observations last September, and have continued them at intervals since. The results observed are of the order of magnitude predicted, and vary, as expected, with the season of the year.

If, continued until next September, the cycle is complete, I shall feel even more sure of having discovered the phenomenon for which I am searching, and of showing that the motion of the ether possesses, both qualitatively and quantitatively, the properties of an electric current—that *an electric current is a bodily forward motion of that same ether whose undulations we call light.*

A DISCUSSION OF THE TROLLEY SYSTEM.

THE following is an abstract of remarks made at a recent meeting of the Engineers' Club of Philadelphia:

Mr. Carl Hering: The trolley system, electrically and financially, is a perfect success. There are at present over 3,000 miles of electric railways in regular daily operation in the United States.

With the exception of the cable, the trolley offers the cheapest method of street car propulsion where the traffic is large and the grades are steep.

A battery that would stand the severe demands upon it would render the storage battery system entirely satisfactory. As it now stands, this system is more expensive than the trolley. I know of but one existing conduit line in regular operation, viz., that at Buda-Pesth, in Hungary. This works satisfactorily. The ground return renders the trolley system a huge lightning rod, with great danger of fire in case of the crossing of wires. Where neither wire is grounded, two contacts are necessary to cause an accident, but where either wire is grounded, one contact suffices.

The lives of persons using telephones are not in danger from the crossing of the telephone wire with the trolley wire.

I know of no authentic record of loss of life through taking the shock from a trolley wire.

The number of deaths in Boston is said to have increased 100 per cent. since the introduction of the trolley system there, but the additional cases were caused by run-overs and similar accidents, not by electric shock from the wires. There is, however, great danger of fire.

Mr. Henry G. Morris: An electric light lineman was killed on a pole in Boston, and it was claimed by the electric light people that there was no current in their wire, and that his death resulted from the crossing of theirs with the trolley wire.

Mr. C. H. Luders: Would not a current of 500 volts passing through a No. 14 telephone wire fuse the wire and thus prevent the current from reaching the person using the telephone?

Mr. Morris: That would depend not only upon the voltage (electro-motive force), but conjointly upon the amount of the current in amperes.

Mr. F. R. Ford: Dr. Massey finds that the resistance of the human body is 1,000 ohms, and that a half ampere (which is equivalent to 500 volts passing through a resistance of 1,000 ohms) will not kill a human being. An experiment has been tried upon a worn-out car horse. One of the wires was wrapped several times around the body of the horse and the other was attached to an iron plate upon which the horse stood. Five hundred and ten volts were then passed through the wire. The horse jumped, but after sustaining the current for 15 seconds, his condition seemed, if anything, slightly improved.

A voltage of 500 is a compromise between requirements of safety on the one hand and the expense of wiring on the other.

Professor L. F. Rondinella: Professor Houston stated at the Franklin Institute that under certain circumstances he would not mind taking a current of over 1,000 volts, whereas under other circumstances 5 volts would be unsafe. A given current, for instance would be much more dangerous if taken in one hand and passed out at the other, so as to traverse the vital organs, than if taken in one arm and passed out through the leg on the same side. A current of 10 volts might be fatal, if applied at the back of the neck.

Mr. Carl Hering: As to the horse mentioned by Mr. Ford, instead of winding the wire about the body, where the hair would act as an insulator, it should have been applied through the hoofs, as would probably be the case with horses on the street. If one's hands are dry, there is less danger than if they are moist. A current taken through water, especially if it contains soda, would be working under conditions favorable to accident. The horse shoe nailed to the moist hoof makes an excellent conductor, and this is, no doubt, why so many horses are killed. A current of 20 volts will make them jump badly.

Mr. William Wharton, Jr.: All animals differ in thair susceptibility to electric shock. The human body offers a higher resistance than that of the horse.

By increasing the size of the conductor we may reduce the tension, and thus make the trolley system as safe as the storage system.

Mr. C. H. Roney: On the experimental road on Ridge Avenue it was found that the cost of a conduit system was higher than that of the trolley, but, on the other hand, the conduit system is much more convenient. It causes no obstruction of the street and there is no possibility of falling wires with their attendant accidents.

The principal objections to the trolley system are the danger of accident through contact with electric light wires, and the obstruction to the fire department in case of fire. A minor objection is the unsightliness of the system.

Mr. Wharton: Inasmuch as the arc light wires are the most dangerous, it is they and not the traction wires that should be put under ground. The trolley system is often charged with accidents which occur through contact with electric light wires. A year or two ago, two men were carrying from a building a show case with metal frames, and an exposed arc light wire, hanging down, touched the frame and one of the men was killed. It would be as just to argue from this that the carrying of show cases with metal frames is a dangerous practice.

Mr. William M. Kerr: The trolley wires are necessarily naked, whereas the arc light wires are insulated.

Mr. Wharton: The insulated wires are all right until the insulating material is rubbed away, and this is very easily done.

Mr. H. B. Hirsch: Is the conduit system in Chicago the same as that used at Buda-Pesth?

Mr. F. R. Ford: I believe that in Chicago is of the Love system, and is not yet in successful operation. Of some 400 electric roads in the country that in Camden is the worst. It uses the old Daft system, with two overhead wires, carrying a current of 200 volts. The line construction is abominable and would not be tolerated elsewhere.

As to the cost: A road with wooden poles, with the rails bonded for the return circuit and with construction otherwise of the cheapest, may be built for $1,000 a mile; while with iron poles, 125 feet apart on each side of the street, with span wire crossing at each pair of poles, and with feeder wires on one set of poles, etc., the cost may reach $5,000 per mile. For feeder wires under ground in wooden troughs, we must add $3,000 per mile of single track, and this will give the most perfect electric railway now known. I understand that the Traction Company is considering the use of a special overhead construction on its Spruce Street line, having a single line of poles on the curb, with arms extending to the middle of the street. At every other pole, or 250 ft. apart, an arc lamp is to be mounted for lighting the street. This construction is no more unsightly than the arc light system now in use upon Green Street, and has only one additional wire, viz., the trolley wire in the middle of the street. The electric light system will use a separate current.

Mr. Carl Hering: I think the companies would object to the expense for the heavy wire required to reduce the voltage below 500, as suggested by Mr. Wharton. A very serious objection to the trolley sys-

tem is that it is liable to start several fires in a house at one time. This danger is greater in Philadelphia, where the ordinances require no guard wires, than in places like Boston, where two guard wires are required.

Mr. Wharton: Such guard wires will, however, be required here also before long. The ordinances now require that the Director of Public Safety shall prescribe the use of such protective appliances as he may see fit. Besides, it is to the interest of the company itself to erect the best possible structure.

Mr. W. C. L. Eglen (visitor): No company has adopted means to avoid interference with the ground return of telephone wires. A wholly metallic circuit, of course, requires twice as much copper wire as the ground return system, but is entirely free from danger of fire. The insurance companies have objected to the use of the ground return system.

Dr. H. M. Chance: Horses and mules have been disabled and often killed, I believe, by a current of 200 volts. In a mine the roadway is wet and the animals often have to travel through water or mud up to their fetlocks. This, of course, makes an excellent contact with the most vulnerable parts of their bodies. In streets the current has to find its way through the comparatively non-conducting hoofs and hair.

Another serious objection to the trolley system is that in the future improved systems will certainly be devised, but those companies who have established their trolley plant will not be willing to adopt these systems.

Mr. Henry G. Morris: At present, the cost of running by the trolley system is 4 cents per car mile less than with horse power. The storage battery is at least as cheap as horse power.

Mr. T. Carpenter Smith: The question of danger to life depends entirely upon how the current is taken. I have taken 1,000 volts of alternating current dozens of times, and 1,500 volts of direct current, in the most dangerous way, but that I am here this evening is due to the fact that my hands were then dusty. It has been stated that the resistance of the human body is about 1,000 ohms, but the testimony in the Kemmler case showed that in this respect no two men are alike. There is no standard. As to the quantity that may be taken, I would not be willing to risk half an ampere. The testimony showed that under certain circumstances one-tenth of an ampere may be fatal. We must consider the voltage and the quantity conjointly. Arc light circuits have a high voltage. They are dangerous to life but not liable to cause fires. A current of 10 amperes is equal to 65 horse power. A trolley system of 500 volts has unlimited quantity behind it.

The Camden road would be much better with a ground return and 500 volts.

The burying of the feeder wires is of no account. They can be insulated when on poles. What is wanted to secure safety is the burial of the trolley wire. Two or three years ago Albany had 55 fires in one night. Owing to sleet the bare wires of the fire alarm system fell upon the trolley wires and the fire system was burned out.

Automatic protectors are all right where there is a good rush of current, but they will not protect in cases where there is only a slight leak. In every telephone there is a small coil of very fine wire. No protective device is successful in protecting this coil, and if it is highly heated it may set the building on fire.

A current of 500 volts will ordinarily not kill, but it will burn terribly. Some years ago, a workman having hold of a rheostat wheel touched a copper bar in an electric light system with only 220 volts. He was burned as badly as if his arm had been held against a red hot plate. I believe he never recovered the use of the arm. Five hundred volts are fatal to horses and mules every time. In New York I have seen horses knocked down by trying to cross a street in which such a current was grounded.

If one-tenth of the amount spent upon the trolley system had been expended on any other, we should have had far better systems long ago.

It has been claimed that the Traction Company would not put up a cheap structure or use poor devices. The answer to this may be seen in their cable system here. They have given us the cheapest possible system, and to Pittsburg and New York the best possible. They will never adopt a better system unless they are compelled to do so, and the more they are made to spend now upon their trolley system, the tighter they will hold on to it.

For the large number of cars of the Traction Company many wires will be needed, and they will have to be loaded up to the muzzle. I believe that the storage system, properly developed, would be found cheaper than trolley. All the experiments with storage batteries have been made upon a small scale and upon the poorest part of the road. Another difficulty is that the engineer in charge of a storage line is hampered by the conflicting private interests of inventors.

Mr. Hermann S. Hering: The storage battery is now being tried in Washington on a large scale, up to 700 horse power, by the Metropolitan Railroad. They have no battery, however.

Mr. Henry G. Morris: Some eight or ten storage battery cars were running in New York a year or two ago. There was a twelve mile circuit with 5 per cent. grades from Eighty-fifth Street to the post office and the Battery. On the return trip the batteries were in the worst possible condition. The running of the line was stopped only by adverse litigation.

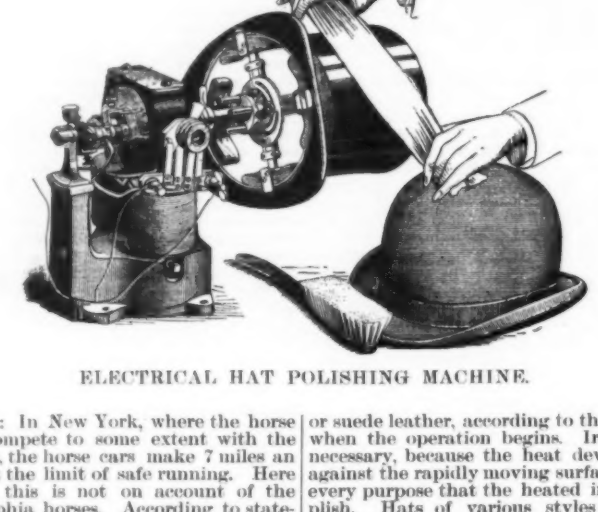
Mr. Carl Hering: I would refer those interested to the report of the operation of the electric roads in Birmingham, England. In that city the cable sytem, electric and horse roads were tried, and accurate records of their operation were kept. The last United States census also contains valuable information on this subject.

There are two principal objections to the conduit system. The first is the cost. The system in Buda-Pesth cost $20,000 per mile, and would have cost $35,000 here. Once down, however, the cost of maintenance is less than that of other systems. The other objection is that the conduit fills with water, but this may, of course, be drained away.

Mr. Howard Murphy: Can we not protect buildings having phone wires even if these should come in contact with the trolley wire? Could not the phone wire be fully insulated?

Mr. T. Carpenter Smith: The trouble is in the telephone itself. It has been suggested that the telephone box might be made of metal to avoid danger from fire, but this would involve danger of shock to the operator.

Mr. Carl Hering: Among the systems tried at Birmingham, the electric accumulator system is the cheapest under ordinary circumstances, and horse cars are the dearest. The cable is the cheapest for heavy traffic on heavy grades.



ELECTRICAL HAT POLISHING MACHINE.

Dr. H. M. Chance: In New York, where the horse car lines have to compete to some extent with the steam elevated roads, the horse cars make 7 miles an hour, which is about the limit of safe running. Here they make 2½, but this is not on account of the slowness of Philadelphia horses. According to statements made by mechanical engineers, the steam dummy is the cheapest system of street car propulsion.

Professor William S. Aldrich (visitor): In Chicago the overhead steam roads can hardly keep up in speed with the cable surface roads. The great advantage of the cable is that the car, after stopping, very soon picks up speed—in Philadelphia, indeed, almost *too* quickly. A steam train cannot do this. The cable gives the most rapid surface transit possible. After it comes steam, and then electricity. The storage battery is best on crowded streets, and the trolley on long stretches of open streets and park. It can pick up speed more quickly than the storage battery car.

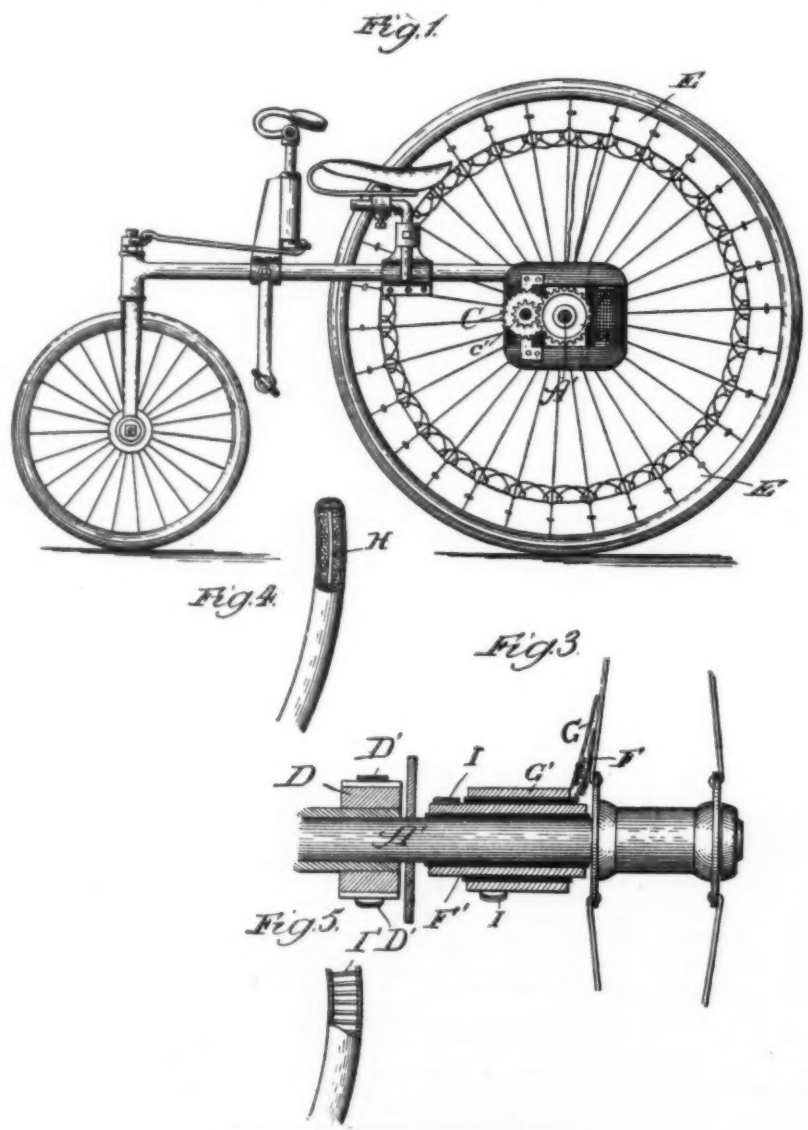
ELECTRICAL HAT POLISHING MACHINE.

THE electrical hat polishing and cleaning machine does away with ironing and shortens the process of renovating an old hat from minutes to seconds or hours to minutes, as the case may be. An inside clutch holds a silk or derby hat of any size without damaging the lining or leather in the least, while revolving at the rate of 2,000 revolutions a minute. The hat attached to this holder is slipped on to a shaft of a one-eighth horse power electric motor connected with an electric light wire or independent battery and started by a lever. The polishing is done with strips of plush, silk, or suede leather, according to the condition of the hat when the operation begins. Ironing is rendered unnecessary, because the heat developed by the friction against the rapidly moving surface of the hat answers every purpose that the heated iron is used to accomplish. Hats of various styles and shapes can be hitched on to the machine, and guaranteed to come out with a gloss and finish never seen even upon a new article. The machine is 8 in. at the base, 7 in. on top, and 10 in. high.

When the saving of time and trouble usually occasioned by waiting for an iron to get heated is taken into consideration, it is apparent that this machine is a great convenience. Slater & Co., agents, 20 West Third Street, New York.

AN ELECTRIC TRICYCLE.

THIS invention by Fulton Gardner, of Chicago, Ill., he describes as follows: A motor, B, of any suitable form, is supported in a case carried by the axle, A'. The armature of this motor is shown mounted on a loose sleeve, *b*, on the axle, this sleeve carrying a gear which meshes with a gear, C, on a shaft, *c*, and this



AN ELECTRIC TRICYCLE.

shaft carries another gear, *c'*, meshing with a gear, *a'*, on the axle, A'. The motor is also provided with the usual commutator, D, and brushes, D'.

Around the circumference of the wheel, and preferably close to the tire thereof, as shown in Fig. 1, I place the cells of the storage battery, E E, secured in any suitable manner to the spokes or tire. There may be any number of these cells desired. In the drawings I have shown them as extending continuously around the wheel in a single row; but it is not necessary that they should so extend, since a less number of cells may be used, or, if desired, a greater number, the number of cells depending upon the power desired. These cells are connected together, as shown, and the negative poles are connected by a wire, F, with a sleeve, F', mounted on the axle, A', while the positive poles are connected by a wire, G, with a sleeve, G', mounted on the same axle. These sleeves being insulated from each other and the axle, brushes, I, are used to convey the current from these sleeves to the brushes of the motor.

In Fig. 4 I have shown a modification in which the tire contains the storage battery, the tire providing one metal and the core, H, the other; and in Fig. 5 I have shown another modification in which the plates, I, of the battery are placed inside of the tire. In each of these cases there will be the same connections with the sleeves, F' and G'.

By means of this construction I am enabled to distribute the weight of the storage batteries more equally and in such a manner as to interfere as little as possible with the efficient running of the machine, while at the same time providing a simple and easily constructed device.

HOEPFNER'S ELECTROLYTIC COPPER PROCESS.

By KARL EILERS.

THIS process differs very materially from that of Siemens, in that the copper is precipitated from a *cuprous chloride* solution, and every one acquainted with the electrolytic disposition of metals will see at once that this is a great advantage, for the same current will deposit copper from a cuprous chloride solution just twice as fast as from a sulphate solution.

Unfortunately, most of my notes on this process are not now at hand, and I must be satisfied with translating an article which appeared in No. 27 of the *Officielle Zeitung der Internationalen Elektrotechnischen Austellung Frankfurt am Main*, in which number both Siemens and Hoepfner's processes were described, both being at the time exhibited at the exposition. The article is as follows:

"While copper sulphate solution is used in the Siemens & Halske process for the electrolytic separation of copper, Dr. Hoepfner, of Giessen, uses in his process a cuprous chloride solution which deposits 2·36 grammes of copper per ampere hour. The liquid, which is a solution of cuprous chloride in strong brine, or in a concentrated solution of chloride lime, and which contains 120 grammes of copper per liter, flows through an electrolytic bath with vertical electrodes, in which the anodes and cathodes are separated by diaphragms, but in such a way that there is nevertheless a constant circulation of the solution along both electrodes. At the cathodes metallic copper is deposited from the solution.

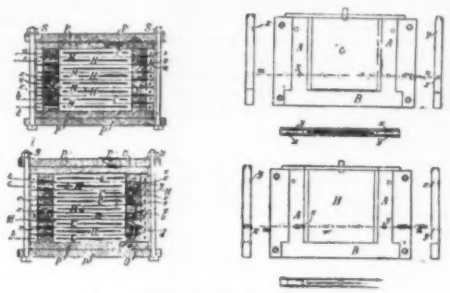
"If the separate cathodes of such a bath have each a surface of one square meter, and the current be 50 amperes per square meter, then there will be deposited on that surface, according to theory, 2·76 kilogrammes of copper per 24 hours, and Dr. Hoepfner asserts that with careful work he can obtain 90 per cent. of the quantity. The loss of 10 per cent. is due to diffusion of the cupric chloride from the anodes through the diaphragm to the cathodes.

"The solution flows continuously from the cathode cells after having passed a large number of them and after having deposited its copper. That portion of the cuprous chloride solution which has been flowing during the same time continuously through the anode cells retains its copper entirely, but, owing to atomic changes, free chlorine is generated at the carbon anodes, naturally proportionate in quantity to the amount of copper deposited at the cathodes. The nascent chlorine, of course, attacks the cuprous chloride, changing it to cupric chloride, and thereby developing positive electromotive force, that is, electromotive force tending to precipitate more copper at the cathodes, so that the electrolysis will take place even if there be no more than 0·6 to 0·8 volt for each bath, while double that potential would be necessary if there were no such chlorine depolarization.

"The cupric chloride at the end is mixed with the cathode solution now freed of its copper, and this mixed solution then should contain, according to the theory of the process, only one-half as much copper as before electrolysis, or about 60 grms. of copper per liter.

"The copper is now, however, no longer in the form of cuprous chloride, but is present as cupric chloride. It is well known that this latter chloride, heated as a dry powder, will lose half its chlorine, which goes off as free chlorine gas. In solution this salt is well adapted, notably when heated, to dissolve sulphides, especially that of copper from its ores, precipitating free sulphur. On the sulphides of silver it acts in the same way, and of this dissolving power Dr. Hoepfner makes practical use.

"The copper ores, which may also contain silver, are ground very fine in a Gruson mill, either crude or after



CATHODES AND ANODES.

having been roasted. They are then raised by an elevator to a platform above the leaching barrels, to which they are afterward transferred as needed.

"The leaching barrels are of wood, a capacity of 10,000 liters each, and rotate on fixed iron wheels, the rotary motion being obtained by sprocket wheel and chain. There must be three or four such barrels. Each of them is filled with 8,000 liters of the heated solution and a corresponding amount of the ore to be treated, and is then set in motion. The time necessary for the leaching varies of course with the character of the ore. It takes from two to six hours to reduce the cupric chloride solution to the cuprous chloride. In practice the so-called "Methodical Leaching" is resorted to, that is, every portion of ore is leached out twice, first by a solution containing a smaller amount of the cupric chloride, and then by another, very rich in that salt, which latter solution takes out the remainder of copper completely.

"When the solution has been sufficiently regenerated, the rotation of the barrel is stopped, the particles of ore fall to the bottom, and the clear solution is drawn off. The solution is then cleaned both mechanically and chemically in special apparatus.

"Besides holding copper, the solution contains silver and certain small quantities of such impurities as lead, iron, arsenic, etc. These are first removed, so as to obtain in the electrolysis afterward a perfectly pure copper. The silver can be precipitated either chemically or electrolytically. An analysis of the copper deposited by the process of Dr. Hoepfner from very impure ores showed only very small quantities of impurities, which were not sufficient to influence in any way the quality of the product.

"The advantages of this process are, according to the inventor: 1. The process yields per unit of current just twice as much copper as a sulphate process. 2. The silver in the ore, which often is of great value, will also be obtained. 3. The conductivities of the solutions are very good and their dissolving power is great.

"After having been cleaned the solution goes to the baths for electrolysis, passes through them, and comes out again as a cupric chloride solution, which is again used as a solvent. It is therefore a continuous process, in which the solution circulates constantly, dissolving and precipitating copper in its various stages.

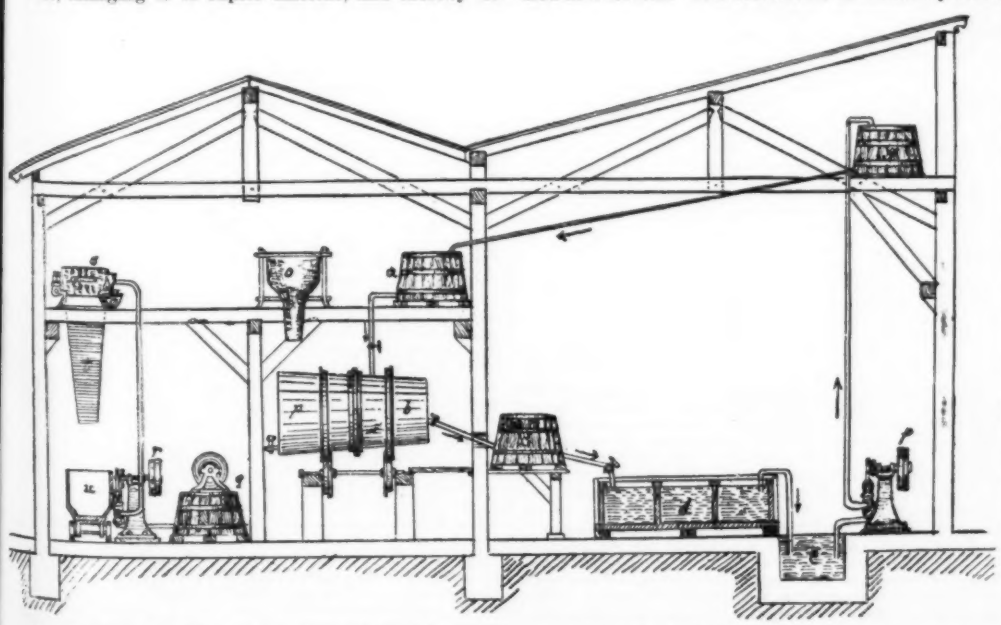
"The ore is forced from the barrel in the form of a thick mush, which is washed in a filter press. It is due to this latter circumstance, *i. e.*, the use of the filter press, and to the compactness of the plant, of which one can get an idea by looking at the accompanying sketch, that the process requires very little room.

"The electrolytic plant for a daily production of 2,000 kilogrammes of copper needs only 800 square meters, while the entire plant, including machinery and all, would require not more than twice that area."

Since the foregoing article was written, many improvements have been made, one of the most important of which is the abandoning of the carbon anodes. These being so expensive, Dr. Hoepfner tried to replace them by another substance, and was finally successful last summer in finding a very cheap anode, and which, like the carbon anodes, does not dissolve. The analysis of the copper obtained from very impure ores, which is referred to near the end of the article, was made in Professor Fresenius' laboratory in Wiesbaden. The results were as follows: Sulphur, 0·0004 per cent.; iron, trace; arsenic, trace; antimony, trace; lead, trace; nickel and cobalt, 0·0012 per cent.; molybdenum, 0·0023 per cent. In other words, this copper was as pure as the best copper.

To show that my opinion of the relative value of the two processes is corroborated by experts and capitalists of Europe, I have but to mention that Siemens & Halske, notwithstanding the fact that they have been the leading electricians of Germany, have not been able to introduce their process in their own country; nor yet in any other to my knowledge, excepting at their own copper works at Kedabeg in the Caucasus. Even there, their process was not successful, and had to be thrown out; so that now the small experimental plant at Martinikenfelde, near Berlin, which I visited in May, 1891, is the sole representative of their process.

Dr. Hoepfner's process, on the other hand, even in 1891 had been adopted by three plants in Germany. Of these the most carefully designed, both from a financial and a scientific standpoint, is doubtless that at Schwarzenberg, which began operations in September last. My latest news from there in December was most favorable for the inventor, and I have since heard that on the strength of that success works were to be put up in France and on the Scandinavian peninsula. That we have not heard more of this process in our country is due to the misfortune that in the matter of the solution of the ore, Dr. Hoepfner has run foul of other United States patents. This, however, cannot in my opinion stand in the way of so good a process for any length of time, and I hope very shortly to hear of its introduction at some works in the United States.—*Engineering and Mining Jour.*



a, reservoir; *b*, leaching vat; *c*, reservoir in which solutions are cleaned; *d*, electric bath; *e*, reservoir; *f*, pump; *g*, reservoir; *o*, ore hopper; *p*, vat; *q*, reservoir; *r*, pump; *s*, filter press; *t*, hopper; *u*, car.

THE HOEPFNER ELECTROLYTIC COPPER PROCESS.

THE INFLUENCE OF AIR AND ITS IMPURITIES ON THE ILLUMINATING POWER OF FLAMES.

By Dr. BUNTE.

DURING recent years it has frequently been observed that the illuminating power of flames, both of candles and of gas, is markedly influenced by the state of vitiation of the atmosphere, whether due to the amount of carbonic acid or water vapor present or to the diminution of its oxygen. I published last year some observations on this subject, from which it appeared that a flame is extinguished in a globe when the proportion of carbonic acid in the air reaches 6 per cent., such air, although containing 11 per cent. of oxygen, being unable to support combustion. It would naturally follow that a much slighter degree of vitiation, such as might arise from the combustion of flames or from respiration, would also exert a perceptible influence on the illuminating power of flames, a circumstance which has indeed been already ascertained by photometric experiments. As we have hitherto had no accurate measurements of this effect, I have had a series of experiments carried out by my assistant, M. Burschell, under my direction. The most general vitiation of the air arises from variations in the amount of carbonic acid and water vapor present, but the way in which the vitiation is produced must also be taken into account.

Carbonic acid may simply be mixed with the air without disturbing the proportion between oxygen and nitrogen (21 vols. of oxygen to 79 of nitrogen), or again it may be produced at the expense of the oxygen. The same thing is true of aqueous vapor, which may be simply derived from evaporation, or from the combustion of substances containing hydrogen, in which case its presence is accompanied by a diminution in the amount of oxygen.

Usually the vitiation of the air is produced by combustion or respiration, in which water vapor and carbonic acid are simultaneously produced, their formation being accompanied by a diminution in the amount of oxygen present. In studying the influence of vitiation on the illuminating power of flames, therefore, it is necessary to examine the effect of each substance separately, and we have consequently made experiments both by mixing the air with carbonic acid and water vapor and by producing these substances simultaneously, the amount of oxygen present being correspondingly lowered.

Among illuminating flames we first tried gas flames, using the bat's wing and Argand burners, as being the most widely used. We afterward made some experiments with the Hefner lamp, which presents special difficulties, because accompanying the diminution of illuminating power there is a modification of the conditions of combustion, shown by a change in the height of the flame. With candles the phenomena are still more complex, because the vitiation of the air not only acts upon the illuminating power, but also on the vaporization of the substance which determines the formation of the flame, so that no exact measurements can be obtained. Since the illuminating power of candles is very variable, even when the composition of the air remains constant, we have not extended our experiments in this direction.

The arrangement adopted is very simple: two flames are used, one at each end of the photometric scale; one is the standard flame, burning freely in pure air, and the other the experimental flame, placed in an atmosphere which can be varied at will. For this purpose the latter flame is inclosed in a large cylinder of glass

1·2 meters in height and 0·33 meter in diameter. The cylinder is closed above and below by iron plates, provided with openings for the entrance of air and the exit of the products of combustion. The area of these openings can easily be calculated so as to have the flame burning under the same conditions as in the open air, the ventilation being just sufficient to remove the products of combustion. This is tested by arranging the flame in the open air to burn just as brightly as the standard, and then placing the cylinder over it and again comparing the brightness; only a very slight difference is produced. This is due to the fact that the light absorbed by the one wall of the cylinder is almost exactly compensated by that reflected from the other. Before each operation we have determined the illuminating power of the flame submitted to the experiment, burning in the open air and in the cylinder, comparing it with the standard so as to eliminate the differences due to reflection and absorption. In order to feed the flame burning in the cylinder with air of varied composition, a large side tube was arranged in the lower iron fastening, into which the vitiating substances, water vapor, and carbonic acid were directed, and thus penetrated with the air into the cylinder. To render the mixture as complete as possible, four disks were arranged at intervals of two centimeters at the bottom of the cylinders, out of which segments had been cut, so that the perforation of one disk came immediately below the unperforated portion of the higher one, and the current of gas was thus several times interrupted, and consequently a thorough mixture obtained. The *composition* of the air feeding the experimental flame was determined in each case by a special analysis. For this purpose a glass tube was arranged so as to end about 3 cm. below the burner, *i. e.*, in close proximity to the flame, and through this could be aspirated at any moment a given volume of air to be tested for carbonic acid and water vapor; the amounts of these substances were found by weighing absorption tubes containing calcium chloride and soda lime. The amount of oxygen could also be found, so that the exact composition of the air feeding the flame could be ascertained.

The method adopted in the various experiments was as follows: First of all the illuminating power of the standard flame, fed by gas passing through a delicate membrane regulator, was measured by the photometer, and then that of the experimental flame burning in the open air and supplied by gas from the same system of pipes. Usually these two flames were arranged so as to consume about the same amount of gas, and to give the same amount of light (100 liters per second of gas and 10 Hefner units of light). The cylinder was then placed over the experimental flame and the illuminating power again taken; as mentioned above, this did not differ appreciably from the former determination. A current of carbonic acid was then sent into the air supply from a receiver and the flame allowed to become of constant illuminating power.

The actual measurement begins at this point and lasts for about an hour or an hour and a half. Throughout this time the conditions are maintained without variation, this being proved by photometric measurements taken every five minutes, and which should be almost constant. At the same time a sample of the air amounting to 4–5 liters is aspirated away and tested for water vapor and carbonic acid. The experiment finished, the supply of impurities is cut off, so as to let the gas burn in pure air again, and the illuminating power rapidly increases until it has arrived at its former value. The cylinder is then removed and the illuminating power again measured.

Influence of Water Vapor.—To determine the effect of moisture, the amount of water vapor present in the air in the cylinder was determined by a delicate hygrometer. This showed about 40 per cent. of relative humidity at 1° C. (corresponding to 0·72 vol. per cent. of water vapor). The illuminating power of the flame was then taken and water vapor introduced into the air feeding the flame by passing a current of air through boiling water and into the cylinder. The humidity rose to 60 per cent. and even 80 per cent. (corresponding to 2·3 vols. of H_2O) without any sensible diminution of illuminating power; at 90 per cent. (24° C.) a diminution of about 12 per cent. was observed, a thick mist being formed within the cylinder. Compared with the action of carbonic acid, that of water vapor is very slight. Without considering this experiment as complete, we have thought ourselves justified in neglecting the moisture present in the air supply in the following experiments.

Influence of the Carbonic Acid.—Circumstances alter when carbonic acid is added to the air, the experiments being carried out as described above. A constant current of carbonic acid was passed into the cylinder, and the amount of carbonic acid determined corresponding to each diminution in illuminating power. The results of this series of experiments made both with bat's wing and Argand burners are given in Table I.

As appears from this the experiments have been made for amounts of carbonic acid varying from 1–5 per cent.; this proportion is relatively very high, and even the lower limit of 1 per cent. is rarely reached in inhabited dwellings on the surface of the ground. Notwithstanding this, the experimental difficulties and the uncertainty of photometric methods rendered it necessary to first of all determine the effects produced between these wide limits, so as to have some idea of the value of the small variations observed in the comparison of photometric processes.

TABLE I.

	Carbonic acid in air, per cent.	Illuminating power.	Diminution of illuminating power.
		In per cent. of original power.	
Bat's wing burner.	0·0	100	—
1	1·10	92·8	7·2
2	1·77	86·4	13·7
3	2·15	81·7	18·3
4	2·88	74·7	25·3
5	3·73	71·1	28·9
6	4·44	68·8	31·2
7	5·11	63·4	36·6
Argand burner.	0·0	100	—
1	2·34	87·6	12·4
2	2·94	84·1	15·9
3	3·87	78·0	22·0
4	4·37	74·8	25·2

The superior limit was obtained by vitiating the air until the flames would no longer burn regularly, and it became impossible to determine their illuminating power with certainty.

We also made some experiments with the Hefner lamp to confirm the effect of carbonic acid in the air. Owing to the feeble illuminating power of these lamps, the photometric bench had to be much reduced, otherwise the Hefner lamp simply replaced the gas flame in the cylinder.

After the flame had burnt for some time in the inclosed space of the cylinder, the temperature was found to have risen. This had no effect whatever on the gas flame, while the Hefner flame grew longer, owing to the increased evaporation of the amyl acetate. Inversely, as soon as the carbonic acid was added, the flame grew shorter, the heat produced being less and the evaporation of the amyl acetate being probably correspondingly diminished. When the stream of carbonic acid was interrupted, the flame again increased in height. As it was impossible to avoid these oscillations in our experiments, we measured the height of the flame on each occasion, and calculated the illuminating power for a flame of 40 mm., by means of the correction formulated by Liebenthal (Journal fur Gasbeleuchtung, 1888, 583), *i.e.*, + 3 per cent. per mm. height of flame. In some experiments in which the proportion of carbonic acid was very high, the height of the flame diminished to 34 mm. Since the method of correction can scarcely be expected to give concordant results within such wide limits, no great accuracy is claimed for the result.

Owing to the difficulties just explained, we have also limited our experiments on the Hefner lamp to this series. In view of the fact that the Hefner lamp is used as a normal unit for the comparison of illuminating power, there would, nevertheless, be some interest in a further detailed examination of this question.

TABLE II.

	Per cent. of carbonic acid.	Illuminating power.	Diminution of power.
		In per cent. of orignal power.	
0	0	100	—
1	1·24	89·2	10·8
2	1·40	88·2	11·8
3	2·98	80·1	19·9
4	3·35	77·3	22·7
5	3·42	75·0	25·0
6	3·53	65·0	35·0

It thus appears that the Hefner, under the conditions of these experiments, is so greatly influenced by 3·5 per cent. of carbonic acid as to render photometric measurements almost impossible. This sensitiveness, greater than that of gas flames, is probably due, at least in part, to the fact that, the heat being less, the supply of air is also less than with a gas flame; and there is no doubt that this is the reason of the abrupt fall in illuminating power when more than 3·5 per cent. of carbonic acid is present.

Influence of the Diminution of Oxygen.—We have seen, at the commencement of this article, that increase of carbonic acid and water vapor almost always coincides with diminution of oxygen, and the determination of the effect of variations in this direction was, therefore, of great importance.

As the experiments described have shown that the vapor of water has only a very slight effect on illuminating power, the oxygen of the air supply can be diminished by the very simple means of burning a small jet of hydrogen in it. For this purpose, a burner fed by hydrogen was placed before the tube by which air was supplied to the cylinder. The height of this flame gave an approximate measure of the amount of oxygen consumed, and since the flame could be easily regulated, the amount of oxygen in the air supply could be correspondingly varied. The exact determination of the diminution of oxygen was made, as in the previous experiments, by aspirating away some of the air, and determining its humidity. The difference between this and the humidity of the air before entering the cylinder gave the amount of moisture added by the hydrogen flame, and consequently the diminution of oxygen. The observations made in this manner, both with the bat's wing and Argand burners, are given in Table III.

TABLE III.

	Diminution of oxygen in p. ct. of total vol. of air.	Illuminating power.	Diminution of power.
		In per cent. of original power.	
Bat's wing burner.	0	100	—
1	0·40	94·8	5·2
2	0·49	90·2	9·8
3	0·58	86·3	13·7
4	0·70	82·9	17·1
5	0·94	79·6	20·4
6	1.21	71·2	28·8
7	1·34	69·6	30·4
Argand burner.			
1	0·51	93·0	7·0
2	0·71	89·3	10·7
3	1·06	85·7	14·3
4	1·45	76·5	23·5
5	1·56	73·5	26·5
6	1·70	67·6	32·4

The water vapor present plays a certain part in the results here given, but does not seem to be of great importance. An exact determination of its effect must be reserved for a special series of experiments.

Influence of the Products of Combustion of Illuminating Gas.—A third set of experiments has been devoted to studying the behavior of a flame supplied by air more or less vitiated by the products of combustion of coal gas itself. The arrangement of the experiment was quite similar to that in the last series, a gas flame being substituted for that of hydrogen. The height of this flame served as an approximate measure of the vitiation of the air. The alteration in the composition of the air was found by determining the carbonic acid and moisture in a sample. It must of course be borne in mind that in addition to these two factors we have the third of diminution of the amount of oxygen. Notwithstanding this, as the vitiation of air by combustion and respiration is generally measured by the amount of carbonic acid present, the results of these experiments have been referred, in the following table, to the amount of carbonic acid present in the air supply.

TABLE IV.

	Carbonic acid in air in per cent.	Illuminating power.	Diminution of power.
		In per ct. of original power in normal atmosphere.	
Bat's wing.			
1	0·26	94·3	5·7
2	0·41	90·6	9·4
3	0·49	87·5	12·5
4	0·54	85·0	15·0
5	0·60	81·7	18·3
6	0·65	80·0	20·0
Argand.			
1	0·18	96·5	3·5
2	0·25	93·7	6·3
3	0·37	84·5	15·5
4	0·43	82·8	17·2
5	0·56	79·7	20·3
6	0·68	77·3	22·7

It follows that a relatively small proportion of carbonic acid, such as might easily be met with in closed rooms, badly ventilated, produces a comparatively large diminution in the illuminating power of a flame, capable of influencing accurate photometric determinations.

When curves are traced from the numbers in Tables 1, 3, and 4, it appears that the vitiation of the air by the products of combustion produces the greatest effect; second in order is the diminution of the amount of oxygen. Carbonic acid may be introduced to a considerable extent without producing much effect. The two kinds of burners do not behave in the same manner. The bat's wing resists carbonic acid alone better than the Argand, while this order is reversed with regard to the lowering of the proportion of oxygen in the air and to the pressure of products of combustion in the air.

If the specific effects of carbonic acid and water vapor be for the moment neglected, and if we look upon these gases simply as indifferent substances, the variation in the composition of the air will appear simply as a dilution, by means of which the proportion of oxygen present is diminished. This proportion of oxygen can easily be calculated from the numbers already given, and may serve as the sole measure of the change. In short, if carbonic acid and water acted purely as diluents without any specific action like the nitrogen of the air, then in every case an equal diminution of oxygen would correspond to an equal diminution of illuminating power. It appears, however, from an examination of the actual figures that this is by no means the case. It is not indifferent whether the diminution is produced by the addition of carbonic acid, or of water vapor, or of both at the expense of the oxygen, but each of these means of dilution produces a special effect. This effect, calculated for the same proportion of oxygen in the gaseous mixture, is greatest for the addition of carbonic acid, less for the vitiation by products of combustion, and still less for the diminution of the oxygen by the combustion of hydrogen. This confirms the statement made above, that the effect of water vapor is relatively small. These observations, the first in a new line of investigation, are still affected by uncertainties; they suggest numerous questions and considerations which I cannot at present follow up, although I hope to return to them at a later period.—*Jour. de l'Eclairage au Gaz; Chem. Tr. Jour.*

CELLULOSE OR WOOD FIBER.*

By Prof. S. P. SADTLER.

THE percentage composition of dry and ash-free cellulose corresponds to the formula $(C_6H_{10}O_5)_n$. It is, therefore, placed in the class of polysaccharides, to which starch and many of the gums belong. It must be understood, however, that this applies to the purified cellulose after the extraction from admixture with other associated principles. This extracting is done by exposing the moist vegetable tissue to the action of chlorine gas or of bromine water in the cold, and subsequent boiling in dilute ammonia, repeating this treatment until the alkaline solution no longer dissolves anything from the tissue or fiber. With many plants, such as cotton, flax, hemp, etc., this reaction, while requiring time and repeated action of the reagents, can be effected with thoroughness. With others, such as jute, straw, and compact wood, the extraction is combined with greater difficulty, and when accomplished yields a product differing in important particulars. It is also often a very difficult matter to draw the line between *mixtures* and combinations of cellulose with non-cellulose constituents of either fibers or tissues.

The following compound celluloses Cross & Bevan, who have made an especial study of this subject, consider sufficiently characterized to warrant special description under class names:

Pecto-celluloses.—Resolved by hydrolysis (with alkalies) into pectic acid and cellulose. Type—raw flax.

Ligno-celluloses.—Resolved by chlorination into chlorinated derivatives of aromatic compounds, soluble in alkalies and cellulose. Type—jute.

Adipo-celluloses.—Resolved by oxidation (with nitric acid) into derivatives similar to those from the oxidation of the fats and cellulose. Type—the cuticular tissue of leaves and fruit.

The pure cellulose obtained from cotton or linen fiber retains the microscopic features of the raw fiber, and thus readily betrays its origin. It is insoluble in all simple solvents, but is first swelled and then dissolved by an ammoniacal solution of cupric hydrate. As pure cellulose is comparatively inert, the reactions which would serve for its identification are few. One of them may be noted, viz., its reaction with iodine. This reaction differs from that of starch in requiring for its determination the presence of an auxiliary reagent of dehydrating power, such as sulphuric or phosphoric acid or zinc chloride. Such a solution containing iodine, dissolved in potassium iodide admixed

* A lecture delivered before the Franklin Institute, Feburary 1, 1892. From the *Journal*.

with zinc chloride colors cellulose instantly a deep blue or violet.

Not much light on the constitution of the cellulose molecule is gained by studying the action of reagents upon it, but many very interesting and technically important derivatives have been obtained. One of the most interesting of these derivatives and of considerable technical importance is the oxycellulose, which is obtained by the action of weak oxidizing agents upon cellulose. That cotton fiber exposed too long to the influence of bleaching powder solution, or even repeatedly exposed to air and light, became weakened or "tendered," had been known for a long time before it was ascertained that this was due to the formation of an oxycellulose, which differed in many of its properties from the original cellulose. The oxycellulose attracts the basic coloring matters from their solutions, and is dyed to full shade and fast color without previous mordanting. It also has a most remarkable attraction for vanadium compounds, which it takes up from the most dilute solutions.

In many reactions, moreover, it bears much analogy to the lignin of the ligno-celluloses.

Probably the most important of the derivatives of cellulose are the nitrates obtained by allowing strong nitric acid or a mixture of nitric and sulphuric acids to act upon cellulose. Taking the doubled formula $C_{12}H_{20}O_{10}$ for the cellulose, the highest nitrate derivative formed is the hexa-nitrate $C_{12}H_{14}O_4(NO_3)_6$, the essential constituent of the true gun cotton. This compound is insoluble in alcohol, ether, or mixtures of both, as well as in methyl alcohol. Acetone alone dissolves it very slowly.

This most explosive variety of gun cotton, according to Eder, is not produced by mixtures of niter and sulphuric acid, but only by using the strongest nitric and sulphuric acids, in which the cotton is immersed at a temperature not exceeding 10° C. (50° F.) for twenty-four hours. The penta-nitrate $C_{12}H_{15}O_5(NO_3)_5$ is best prepared according to Eder's method by dissolving the hexa-nitrate or explosive gun cotton in nitric acid at 80°—90° C. (176°—194° F.) and precipitating by concentrated sulphuric acid after cooling to 0° C. (32° F.) After washing the precipitate with water and then with alcohol it is dissolved in ether-alcohol and again precipitated with water. This nitrate, of which small amounts may be formed in the manufacture of explosive gun cotton, is soluble in the mixture of ether-alcohol. The tetra and trinitrates $C_{12}H_{16}O_6(NO_3)_4$ and $C_{12}H_{17}O_7(NO_3)_3$ are generally formed together when cotton is nitrated with a more dilute nitric acid, at a higher temperature and for a much shorter time than that given for the hexa-nitrate. This mixture constitutes collodion pyroxyline and is soluble in ether-alcohol, acetic ether, acetic acid or methyl alcohol. The dinitrate $C_{12}H_{18}O_8(NO_3)_2$ always results as the final product of the action of the alkalies upon the higher nitrates, and also from the action of hot somewhat dilute nitric acid on cellulose. It is the lowest derivative attainable, a mono-nitrate having not as yet been formed.

The technical uses of these nitrated derivatives of cellulose are very important. An extremely interesting lecture was delivered in this hall a few weeks ago by Professor Munroe, of the Naval War College, of Newport, in which the characters of the explosive gun cotton were discussed and its properties narrated. An equally interesting one might be made upon the now numerous applications of the lower nitrates, constituting as they do the bases of collodion or wet plate photography, of the manufacture of celluloid and of pyroxyline varnishes. We will, however, pass on at present to note the chemical characters of the compound celluloses, the classification of which I have already given.

The first class, the pecto-celluloses, as the name indicates, are compounds yielding pectic acid when the cellulose is liberated from its combination. Thus, in the treatment of raw flax, the retting and bleaching processes are designed to break up this natural compound, the soluble pectic acid being washed away. Dilute alkalies effect the same result, and this treatment is the one often employed in plant analysis to isolate the cellulose.

The third class, the adipo-celluloses, includes the cuticular tissue of fruits and of fibers such as cotton, straw, esparto, etc. Under the action of boiling nitric acid, these tissues are resolved into cellulose on the one hand and a series of fatty acids or products of their decomposition, suberic and adipic acids, such as are obtained from cork tissue, whence the name adipo-celluloses for the class.

In the second class, the ligno-celluloses, we have included by far the most important and interesting of the compound celluloses, viz., the different forms of woody tissue and lignified fibers, such as jute. The last mentioned fiber indeed shows so clearly the nature of the combination between cellulose and what is termed lignin that a study of it has thrown much light upon the characters of the whole class, and has aided chemists in getting a clear understanding of the methods for isolating cellulose from its combination in the compact woods, which are now so largely used as a source of paper-making material.

Jute is a compound of twenty-five per cent. non-cellulose or lignin and seventy-five per cent. cellulose. The non-cellulose constituent is more readily attacked by reagents than the cellulose. Thus if the compound fiber be first boiled with a weak solution of an alkaline hydrate and then exposed to moist chlorine, the non-cellulose is attacked, and, on subsequent boiling with sodium sulphite solution, the decomposition into cellulose and soluble non-cellulose derivatives is complete. Dilute nitric acid also attacks the non-cellulose, resolving it into soluble products, and can be used to isolate the cellulose, but it attacks the latter somewhat also.

Wood consists of about two parts of cellulose in admixture with one part of lignin. Very characteristic color reactions are obtained by moistening any of these lignin-containing compounds with phenols, such as phloroglucin and hydrochloric acid. They are also colored carmine by an alcoholic solution of pyrrol and deep yellow by solution of aniline sulphate. They take up organic dye colors very much like the oxycellulose before referred to. Among the decomposition products of the lignin or non-cellulose have been found vanillin, coniferin and several wood gums allied to gum arabic. Indeed, a recent writer places lignin, because of its composition, among the class of gum resins. He has found in the products of the sulphite process for preparing wood pulp, as well as in those of the soda process, transparent resinous substances which are very similar in reaction to the arabic acid of natural gum arabic. He therefore is led to offer the following theory of these two well known chemical wood pulp processes. If wood is boiled under great pressures with caustic soda, the lignin is decomposed. The gummy matters, resins and phenols, are dissolved and the volatile compounds, *e. g.*, terpenes, etc., escape. Cinnamic aldehyde and vanillin polymerize and coniferin is decomposed. It is well known that sulphurous acid has a decomposing or polymerizing effect upon many groups of organic compounds. In the sulphite process, it first decomposes lignin and then the free arabic acids decompose the sulphite of lime, hereby forming the calcium salt of the arabic acid which remains in the solution while the free sulphurous acid escapes. The author is of opinion that the sulphite process is in the main hereby explained. The terpenes and aldehydes mostly polymerize and escape, together with the other volatile aromatic compounds of the woody matter, as well as the sulphurous acid, while the non-volatile substances, *e. g.*, the resins, are left, parts of which remain as the calcium salts of the resin acids.

The technical applications of this class, as said before, are already of enormous importance. The increasing use of wood pulp as a paper-making material is the explanation of this. We will now take up for brief notice this most important of the cellulose industries. Wood, as before stated, contains cellulose in combination with lignin, together with mineral salts and some little coloring resin. The proportion of these constituents varies somewhat in different varieties of wood, as shown in the accompanying table from Muller.

	Birch.	Beech.	Lime.	Pine.	Poplar.
Cellulose.....	55·52	45·47	53·09	56·99	62·77
Resin	1·14	0·41	3·93	0·97	1·37
Aqueous extract.....	2·65	2·41	3·56	1·26	2·88
Water	12·48	12·57	10·10	13·87	12·10
Lignin.....	28·21	39·14	29·32	26·91	20·88

The practical problem now is to extract the cellulose in such condition as to enable it to answer the requirements of the paper maker, viz., strength and length of fiber, which give it felting power, and for finer papers freedom from resinous and coloring impurities, such as would prevent its use as a mixing ingredient or substitute for linen cellulose.

We divide the wood pulp methods into the two great classes of mechanical and chemical.

In the mechanical wood pulp process, the wood, cut into blocks, is pressed against revolving grindstones, the surface of which has been roughened by the cutting of grooves. The wood is placed so that the revolving stone shreds or tears the fibers laterally and not transversely to the line of the fiber, while a stream of water, kept flowing over the stone, washes off the fiber as rapidly as it is loosened. Even then the fibers are relatively short as compared with those obtained by the chemical processes. The pressure of the blocks of wood against the stones is maintained either by screws capable of adjustment as required or by hydraulic pressure. The pulp as washed off the stones is passed over screens, which retain larger fragments to be ground again and allow the finer pulp to pass through, and this is then farther sorted by sieving.

The quality of the mechanical pulp is improved by steaming the wood thoroughly before shredding, so that the wood being softened a longer fiber may be torn off. Such mechanical wood pulp is made and comes into commerce under the name of "steamed pulp." The specimens shown are from the Androscoggin Pulp Company, of Brunswick, Me., and are mixed spruce and pine. The steaming of the wood is continued for eight to ten hours at a pressure of about forty pounds, and drip valves are attached to the upright boilers used, so that the wood is not soaked in hot water, but exposed to the action of steam only.

Paper made from mechanical wood pulp is very liable to become discolored by the action of air and light, the ligno-celluloses being much more readily acted upon than the celluloses isolated from them. This fiber is, moreover, of very slight felting power on account of its shortness, but it is cheap, and is used in large amounts for filling material, or it may be exclusively for cheap newspapers.

In the preparation of chemical wood pulp, on the other hand, the lignin or non-cellulose constituents of the wood are decomposed and eliminated, so that a relatively pure cellulose remains, in amount varying with the process employed and the kind of wood taken. The processes that have been found applicable for this decomposition of lignin and separation of cellulose are classified as follows by Cross & Bevan, in their *Paper Making:*

VIEW OF THE CHEMICAL PROCESSES FOR DISINTEGRATING WOOD.

(1) *Aqueous Alkalies.*— Hydrolysis aided by alkali directly, also indirectly by combination with products of resolution. (Watt & Burgess, 1853; Houghton, 1857.)

(2) *Solutions of Alkaline Sulphides.* — Hydrolysis, aided by alkaline bases directly and indirectly by combination with the products. Reversal of hydrolysis lessened by presence of reducing agent. (Jullion, 1855; Blitz, 1883; Dahl, 1884.)

(3) *Water.*—Hydrolysis, aided by acids formed from the wood. Limit of action determined by reversal of hydrolysis, *i. e*, dehydration aided by oxidation. (Fry, 1867.)

(4) *Water, together with Neutral Sulphites.*—Simple hydrolysis. Products removed from sphere of action by combination with base and sulphite. Oxidation prevented by presence of sulphite. (Cross, 1880.)

(5) *Aqueous Acids.*—*a.* Oxidizing and hydrolytic. Nitric acid. (Coupier and Mellier, 1852; Barre and Blendel, 1861.) Nitro-hydrochloric. (Orioli, 1865.)

b. Simply hydrolytic. Hydrochloric acid. (Bachet and Machard, 1864.)

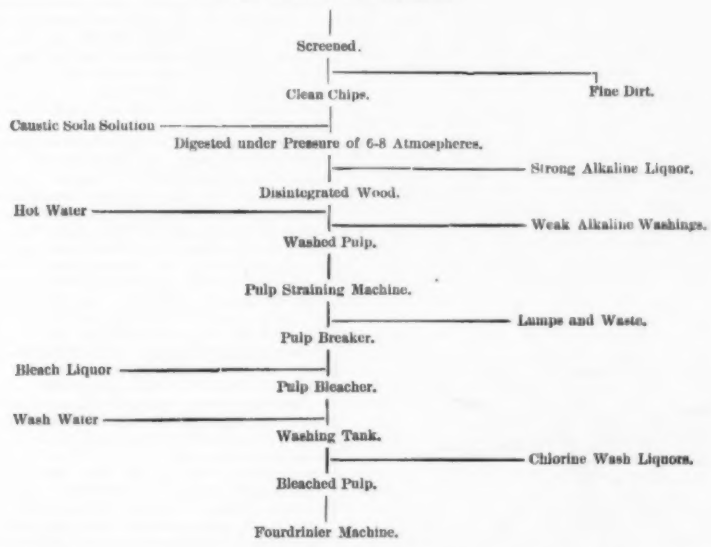
c. Reducing and hydrolytic. Sulphurous acid. (Tilghman, 1866; Pictet, 1882.)

(6) *Bisulphites.*—Hydrolysis aided primarily by sulphurous acid and secondarily by combination of products with bisulphites, also by prevention of oxidation. (Tilghman, 1866; Mitscherlich, 1874; Ekman, 1881; Franke, 1881; Graham, 1882.)

The processes in practical operation at the present time have narrowed down to those under two of these headings, viz., soda pulp processes and "sulphite," or, more correctly, bisulphite pulp processes.

The first of the soda processes was that of Watt & Burgess, and this, with some modifications, is still in successful use to-day. It depends, as was mentioned before, upon the fact that the lignin is decomposed by the caustic alkalies under pressure, and the products of the decomposition go into solution. Its drawbacks are that under the conditions needed to complete the disintegration of the wood, the cellulose portion itself is attacked, and hence the yield of finished pulp is smaller than by some other processes. And when the regeneration of the soda was incompletely carried out, as was often the case, the process was an expensive one. Great improvements have been effected in this matter, however, and with the present high percentage of recovery, the process makes a better showing. A diagram, showing in graphic form the several stages of the Burgess soda process as carried out in this city, is shown.

WOOD CHIPPING MACHINE.



Of the sulphite processes mentioned in the diagram already given, that which is most generally employed in this country is the Mitscherlich, while in England the processes of Ekman and Franke, as modified by Partington, have been tried in addition. The Mitscherlich and the Franke processes use bisulphite of lime, while the Ekman process takes a bisulphite of magnesia. The sulphurous oxide, of course, is produced by the burning of sulphur or pyrites, and this gas, after being cooled, is passed into milk of lime, placed in large tanks, which are used either singly or connected in series for more complete absorption. This bisulphite liquor then acts upon the chips in closed boilers or "digesters" under a pressure of ninety pounds for some nine to ten hours. A longer boiling at somewhat lower pressure is also used in some cases.

Of the side products, shown to the right in the diagram, the strong alkaline liquor is run to the evaporator to be evaporated, calcined, dissolved, and causticized for renewed use; and the chlorine wash liquors are used in dissolving chloride of lime for fresh bleach liquor.

After the completion of the boiling, the mixture is blown out into large vats provided with drains in the bottom to allow of the escape of the spent liquor. It is then thoroughly washed, mixed with water and pumped on to screens to allow of the removal of chips or impurities. The screened pulp is then felted and is ready for delivery as unbleached pulp. In this condition it is very prone to discoloration, usually turning

pink and finally brown when exposed to atmospheric influences for a time. The reason is very simple from a chemical point of view. The reducing action of sulphurous acid, it is well known, is always a transient change, and is in time overcome by the atmospheric oxidation following exposure to air and light. If, however, the well-washed pulp is thoroughly bleached by an oxidizing agent like chloride of lime, the pulp is no longer affected by atmospheric influences.

Sulphite pulp in the United States is prepared chiefly from spruce wood, and when properly bleached gives an almost pure cellulose, white and of strong fiber.

The wood pulp production of the United States more than trebled during the decade between 1880 and 1890, and now employs between 200 and 300 factories, of which the larger number run, of course, on mechanical wood pulp, although the chemical wood pulp processes are gaining ground relatively faster, and are at present coming into greater favor.

THE LIFE OF AN ANT.

By E. A. BUTLER.

THE way in which an ant's nest originates is involved in some obscurity, and it is quite possible that the method is not always the same. Sir John Lubbock has shown that a nest may exist for years without the presence of a female, or "queen" as she would be called, and, on the other hand, if such be present, the number need not, as in the case of bees, be restricted to one. Though a nest which has once been established may continue to exist, at least for a time, without the intervention of any females, still it is most probable that for the origination of a *new* nest we must look to the initiative taken by a queen. The marriage flight then being over, the young bride, or queen as she may now be called, even though she has no subjects to rule over, has apparently several courses open to her.

She might, for example, return to the nest which produced her, or to some other already existent community, and contribute her share toward renewing or enlarging what is already well established. Or again, she might, if of a more independent turn of mind, get some stray workers to help her in founding a new colony, of which she would be both the mother and ruler; or, thirdly, there is open to her, supposing her powers equal to the task, the possible course of taking upon herself all the duties of maternity and colonization, and laboring with her own feet and jaws to prepare a home for and to support her progeny till they are sufficiently advanced in age to take their proper share in life's burdens.

There is scarcely sufficient direct evidence to warrant a decision as to which course would generally be adopted. Sir John Lubbock invariably found that when he introduced queens into queenless nests they were not accepted by the inhabitants, but were at once attacked with energy. Whether this antipathy was owing to a natural tendency or was the result of the insects in question having been long unaccustomed to the society and rule of queens is, however, doubtful. And since any eggs that may be laid by workers, a circumstance that sometimes happens, invariably produce males only, it would seem that a nest from which females are permanently excluded must sooner or later suffer extinction. Moreover, as showing that adoption into a strange nest may sometimes be the lot of the newly hatched queen, McCook records such a case as having come under his own observation in America.

Sir John Lubbock's experiments in the direction of inducing females to rear their own young without help, and so start a new nest, were more successful. One day, in the middle of August, 1876, he found two pairs of the little red stinging ant, *Myrmica ruginodis*, flying in his garden. He placed them quite apart from other examples of the same species, and provided them with all needful requisites in the shape of earth, food and water. All through the winter they remained alive and healthy—a somewhat unusual circumstance, as the males (Fig. 1) appear generally to die in the autumn. In this case they did not die till the spring, just about the time when their partners laid their first eggs. During the course of the summer various eggs were laid at different dates, many of which hatched in due course, passed safely through larvahood and pupahood, and at last reached the perfect state, coming out as workers some thirteen or fourteen weeks after the laying of the eggs.

FIG. 1.—Male of *Myrmica ruginodis*. Magnified six diameters.

All attentions that they needed during this time were, of course, rendered by the parent queens, who thus proved that they had the power, if opportunity should call for its exercise, of founding new colonies. Other observers, however, experimenting with different species, have met with less satisfactory results, and it is, of course, possible that what one species can do in this respect another cannot. The same remark applies to their whole economy; for while the broad facts involved in their social habits are pretty much the same in all, yet no two species are exactly identical in habits, and one must guard against concluding that what is true of one kind is therefore necessarily true of another.

All ants, of whatever species, commence their life as eggs; these are minute oval bodies, of whitish or yellowish color. When laid, they have to be stowed away in suitable chambers excavated in the nest, and must be conveyed thither by the workers, by whom also they are carefully guarded. In carrying the eggs the mandibles are used, but to minimize the difficulty of transit, and the risk of damage, which would result from carrying such minute objects singly, they are caused to adhere together by their sticky surfaces, and can thus be conveyed away in batches. It is hardly necessary to point out that what are popularly called "ants' eggs"—the large yellowish or cream-colored oval objects which one often finds lying about in great numbers in the passages of the nest on removing the roof, and which are used as food for pheasants, singing birds, and fishes—are not the objects we are now speaking of, but are the pupæ of the ants, which are looked after by the workers quite as assiduously as the true eggs. Their size alone is sufficient to check any such misconception, and to suggest their true character. But there are often to be found in ants' nests batches of minute eggs, truly so called, which are not those of the ants themselves, though guarded with as much care as their own. They are little dark-colored objects, the eggs of aphides or plant lice, which are kept by some ants as domestic animals, and of which we shall have more to say in another paper.

From the egg is hatched, in a few weeks' time, a maggot-like grub (Fig. 2 A), whitish and semi-transparent, and covered with short hairs; it is plainly divided into segments, but has no legs. It is rather conical in shape, tapering toward one end, at which is situated the mouth, furnished with a couple of tiny hooks, which, though suggestive of jaws, seem to be of little use as such. These larvæ are perfectly helpless, and cannot even feed themselves. Here is one of the penalties attendant upon the development of the social instinct; the insect is never left to itself, but has to be looked after and cared for from the day of its entry into the world as an egg till the time of its extrication from the last skin it will ever shed. In the case of a solitary insect, such as by far the greater number of insects are, no such care would, as a rule, be taken; the eggs would be left to themselves, and the larvæ would be capable of providing their own food, or if not actually doing so, yet of feeding themselves from a store previously accumulated by the mother. With the hatching of the eggs in an ant's nest, therefore, the duties of the workers are enormously increased. Scores of little mouths have to be kept supplied with suitable food, each one several times a day, and but a brief intermission of their attentions would probably be quickly attended with a fatal result. The food is elaborated by the nurses themselves in their own stomachs, and is supplied to the gaping mouths of the larvæ through their own mouths. Now as the eggs are not all laid at one time, there are frequent hatchings going on during the summer months, and in the same nest there will be grubs of different ages; these will, of course, require differing quantities of food, and possibly even food of varying quality, according to age and the sex of the insects that are to result from them. Hence method has to be introduced into the management of the commissariat, and the nurslings are divided into classes according to their size.

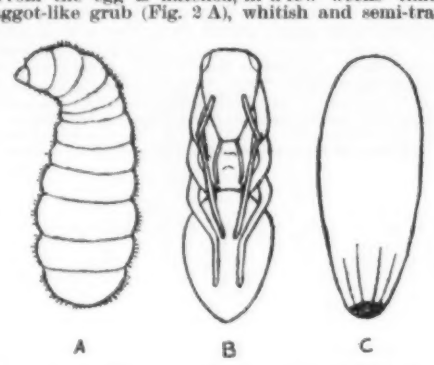


FIG. 2.—A. Larva. B. Pupa. C. Cocoon of ant.

But the young maggot-like ant is a troublesome little creature, and needs a good deal more attention than what is involved in providing it with meals. Cleanliness is an important element in its education, and as it cannot clean itself, this duty also falls upon the nurses, which perform the necessary operations with their mouth organs. Just in the same way, too, the workers will clean one another, and Sir John Lubbock found that the ants he had marked with spots of paint, so as to be recognizable again, had the spots in a little while removed by their friends, a delicate personal attention which suggests curious ideas of etiquette.

For the attainment of the most healthy condition, a certain degree of warmth and moisture is necessary for the larvæ, and as the various chambers in the nest will usually differ somewhat as regards these conditions, there results the necessity of carrying the babies about from place to place. The mandibles are again called into requisition for this purpose, and like a cat carrying her kittens, the nurses gently take up the grubs in their jaws, and hurry with them along the galleries from nursery to nursery; if the sun shines, they will be taken to the topmost galleries, not indeed that they may be directly exposed to its rays, for this would apparently be injurious, but that they may be as near to its influence as the thickness of the covering stone or roof of the nest will permit.

When the weather is cloudy, or when night comes, they must be carried down; or again, let but the nest be disturbed so as to admit the direct sunlight, and plenty of pairs of eager jaws are ready at a moment's notice to seize and hurry off below ground their fat and fleshy charges, until, in a few minutes, none are left exposed. Of course this may be quite as much for the sake of saving the treasures from the possible grip of the rash intruder as to remove them from the influence of the direct sunlight.

The length of the larval life varies greatly. One of the common red ants (*Myrmica ruginodis*) appears to be among the quickest in development, and in some of Sir John Lubbock's nests this species remained less than a month in the larval condition. On the other hand, some of the larvæ of the yellow ant (*Lasius flavus*), viz., those of the autumn brood, are very tardy in their progress, and remain grubs throughout the winter, lying torpid in the deeper parts of the nest, destined not to complete their growth till the spring sunshine reawakens the population of the nest, and supplies them again with energetic and painstaking attendants. What happens to the grub at the close of larvahood depends upon the species; all change into a chrysalis, but with a remarkable difference, the reason for which is not known. Those which when fully grown have not the power of stinging, as for example the common black ant of the garden, envelop themselves in a silken cocoon, while those which do sting, such as the familiar red species before mentioned, have no such covering, but simply cast the larval skin and remain naked as pupæ. This rule, however, is not absolute, and Latreille discovered that the larvæ of one of our common dark colored stingless ants, *Formica fusca* (Fig. 3), sometimes spin cocoons and sometimes do not. The pupa of an ant (Fig. 2 B) is similar to that of a bee, but not like that of a moth, inasmuch as it exhibits distinctly the outline of the various parts and appendages of the future insect, such as the head, legs, antennæ, etc. But the whole insect is covered with a thin skin, which has to be removed when it reaches maturity before it can make any use of its perfected limbs. In case of the stingless ants, then, this insect, enveloped in its thin skin, but with its various parts more or less distinctly revealed, is inclosed in its silken shroud like a mummy in a sarcophagus, the whole constituting a smooth oval body, with a dark dot at the end opposite that at which the head lies (Fig. 2 C). These are the familiar so-called "ant's eggs" above mentioned, and they have to be carried about from one story of the nest to another in the same way as the larvæ. In fact, the anxiety of the workers for the welfare of these objects is extraordinary, and those who have kept ants' nests for observation have made use of this passionate devotion to their young, whether as larvæ or pupæ, to induce the ants to travel in such directions as may be desired for the purposes of experiment, and the discovery of a store of larvæ or pupæ in any spot is to a worker ant quite as strong an incentive to exertion, and quite as important a piece of news to be communicated to its fellows, as it would be to come unexpectedly upon an abundant supply of the most delicious food.

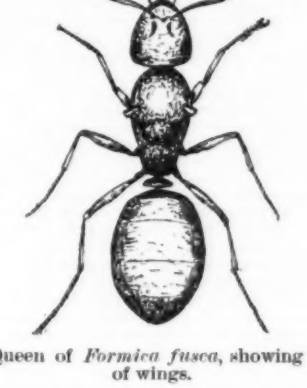


FIG. 3.—Queen of *Formica fusca*, showing remnants of wings.

The change to the chrysalis condition is, of course, not effected by the larvæ till after it has spun its cocoon, for when once it passes into this stage it becomes more helpless than ever before, and would, but for the assistance of the nurses, perish where it is and in direct consequence of its own act of walling itself round, and so cutting itself off from the world by a continuous and impenetrable barrier of silk. Here, again, appears strongly the helplessness of the individual member of the social community, as contrasted with the independence and power of the solitary insect. The caterpillars of many moths, as is well known, before turning into the chrysalis condition, surround themselves with a silken cocoon, which is sometimes, as in the case of the puss moth, of so hard a consistency as to resist strong pressure, and to offer considerable opposition even to the entrance of the point of a knife. Within this covering lies the limbless pupa, apparently as effectually doomed to a lifelong imprisonment as any captive thrown into the old Bastile. And yet without any assistance from outside, or any means other than what its own body supplies, the imprisoned moth first throws off its hard and crisp pupa skin, and then works its way through the walls of the cocoon, and after a little pause triumphantly proceeds, in its own unaided strength, to the business of its new life. Not so the ant, however; for liberty, and indeed for life itself, it is in many cases beholden to the same unremitting attention that has presided over its destinies hitherto. With a degree of intelligence which is truly remarkable, the nurses divine the right moment when the imprisoned and invisible ant is ready for release. Then, with their jaws they nibble and pinch at the loose-fitting investment and make a neat slit down one side, and thus open the prison doors. But even then the captive cannot avail itself of the liberty which is thus brought within its reach. It must be hauled out by the nurses, and stripped of the thin skin which still enshrouds its limbs; those limbs must then be helped into position, and the invalid stroked, caressed and fondled with antennæ and legs till it begins to collect its senses and becomes conscious of its powers. It must then be led and guided about the nest, till it is familiar with the details of that home in which, if its structure fits it for that purpose, it must now take its place as one of the great band of toilers, and show by its deeds that the care that has been expended upon its education has not been in vain.

Some three or four weeks will have been passed by the ant in this state of inactivity, during which time it has

taken no food. But when it enters on its perfect condition hunger will again begin to assert itself, though the food taken will not, as heretofore, contribute to swell its bulk, for now waste and repair will be balanced, and the ant has attained its full size. Among the workers there is often a good deal of variation in size; there are large ones which are called workers major and small ones called workers minor, and often intermediate sizes also; but it must not be assumed that the minors will grow into majors; whatever size the worker ant has on quitting the pupa skin, that it retains throughout the remainder of its life. The same applies to the males, and to the females as well, except in so far as the development of the eggs increases the size of the abdomen. The range of difference among the workers is not the same in all ants. Take, for example, three of onr commonest species; two of these, the yellow ant (*Lasius flavus*) and the wood ant (*Formica rufa*), show great inequality in size in the workers, while the common garden ant (*Lasius niger*) has them much more uniform. The larger workers have often a proportionately larger head, indicating larger muscles, and consequently more power in the jaws, whence it has been generally supposed that such forms are intended to act as soldiers and do the chief part of the fighting of the community, but pugnacity is by no means the monopoly of those big-headed forms, and the little workers are quite ready to do battle if occasion requires.

Up to the point to which we have now conducted it, our ant has passed through a life of considerable monotony. Its most extensive journeys have not extended over more than a few inches of territory, and even these it has performed by the aid of others; its sole occupation, when it has been doing anything more than simply lying still and "developing," has been eating, and for this, too, it has had to be a pensioner on the bounty of friends. It has been from its birth an inhabitant of underground galleries and tunnels, and has never seen the light of day, except by accident. But now a vast change takes place; the whole world is before it, and if it is a worker, there awaits it a life, extending over years it may be, full of variety and activity, and crowded with incident and adventure. It is here that the social insect gets the advantage of the solitary one. The chief businesses that engage the attention of the latter are provisioning and love. The former is often uniform and prosaic enough, and even the latter, while it may involve a certain amount of incident and romance, is still as a rule an affair of such brevity that there is hardly time for anything very striking in the way of adventure to take place, before the adventurer is called upon to pay the debt of nature. But with the development of the social in-

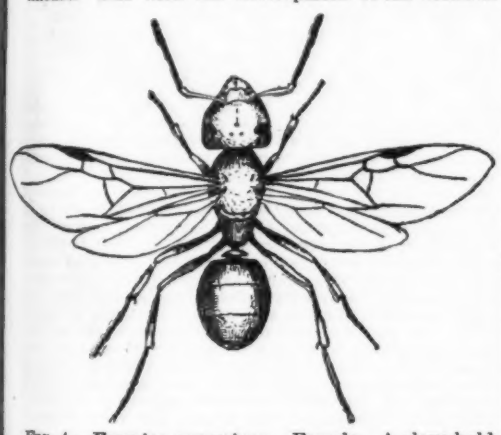


FIG. 4.—*Formica sanguinea*. Female. A slave-holding ant. Magnified four diameters.

stinct there comes an indefinite number of new responsibilities and endless opportunities of variety, resulting from the complexity of the life and the increased length of it, which seems to be the necessary accompaniment of the higher type of existence. To the threshold of this life of variety and incident we have now brought our ant.

The exact nature of the occupations to which a worker ant devotes itself on attaining maturity depends somewhat upon the species, but there are, as a rule, certain well defined heads under which their labors may be classed. Besides the care of the young, which we have already noticed, their chief duties will consist of the construction, enlargement and repair of the nest, the hunt for provisions, and the defense of the colony. The satisfying of these claims will usually be sufficient to occupy all their time, so that their life becomes one of incessant activity, and their industry is well known and proverbial. Their activity may extend even into the night, for if daylight does not suffice to complete necessary work, it must be continued after dark, and Sir John Lubbock mentions having watched an ant which worked continuously for nearly sixteen hours, from early morning till late at night, carrying larvæ to the nest.

The character and situation of the nest depend entirely upon the species. The conical or rounded heap, of earth or twigs, commonly called an "ant hill," is not always present, nor does it follow that, if ant hills are made, each distinct hillock represents a separate and independent community. While it very frequently happens that an entire community is located under one roof, such is by no means universally the case, and, therefore, the terms "ant hill" and "ants' nest" are not necessarily interchangeable; often one colony will have three or four distinct dwellings, in any of which its members would be at home. Occasionally some communities build much more extensively than this. M. Forel, indeed, cites a case in which a single community of ants of a very active species (*Formica exsecta*) possessed as many as two hundred dwellings, which were spread over a circular area measuring nearly a quarter of a mile in diameter. So completely had they appropriated this area that, with the exception of a few nests belonging to a very agile kind, no other species of ant dared show their faces in it. Many and fierce, no doubt, had been the conflicts before this undisputed sway was established, for *Formica exsecta*, though a delicate insect, is a ferocious fighter. Sir John Lubbock thus graphically describes its battles: "They advance in serried masses, but in close quarters they bite right and left, dancing about to avoid being bitten themselves. When fighting with larger species, they spring on to their backs, and then seize them by the neck or by an antenna. They also have the instinct of acting together, three or four seizing an enemy at once, and then pulling different ways, so that she on her part cannot get at any one of her foes. One of them then jumps on her back and cuts, or rather saws, off her head."

While several ant hills, as we have seen, may belong to one community, it sometimes happens, on the other hand, that a single hillock is shared by two communities, belonging to distinct species, one half being occupied by the one party and the remainder by the other, each maintaining a separate organization, though domiciled under a single roof. Thus the yellow ant (*Lasius flavus*) and one of the races of the red stinging ant (*Myrmica scabrinodis*) not unfrequently live side by side in this way, and the distinctness of their establishments is evidenced by the fact that if the nest be disturbed, as for example by the dislodging of a stone, the two parties on rushing out to discover the cause of the disturbance will sometimes come into conflict, and a desperate struggle will take place, each apparently mistaking the other for the authors of the disaster. But there is another way in which a single ant hill may shelter more than one species. Small and weak species sometimes live in the nests of larger and more powerful ones, completely intermixed with them, though the bond of connection is not always the same. There is a minute ant called *Stenamma Westwoodii*, which is never found except in the nests of the wood ant and an allied species, and so dependent do they seem on their hosts that, when the latter change their abode, their little companions go with them. They are certainly not on terms of hostility to the larger species, which, indeed, take but little notice of them. Not so, however, with another minute ant called *Solenopsis fugax*. These are real parasites. They make galleries in the walls of their hosts' nests, whence they issue to invade the nurseries of the latter and carry off the young as food. Once within their galleries, they are safe from retribution at the hands of their defrauded hosts, as the latter are too large to get into their tiny burrows. Sir John Lubbock has very aptly compared their depredations to what would be the state of affairs with us, "if we had small dwarfs, about eighteen inches to two feet long, harboring in the walls of our houses and every now and then carrying off some of our children into their horrid dens."

But further, a smaller and weaker species may be in the nest of a larger one as slaves, or at any rate, helpers. Though the most remarkable of the slave-making species are not British, we have in this country one kind which is addicted to such habits. It is very much like the wood ant (*Formica rufa*), and is sometimes called the red ant (*F. sanguinea*). (Fig. 4.) The worker has a red head and thorax, and a black body; it makes raids upon neighboring nests of different species, capturing those larvæ and pupæ which will produce workers. These, on coming to maturity, finding themselves surrounded only by members of a different species, and having no young of their own to look after, calmly submit to their fate, adapt themselves to their circumstances and set to work to tend the young of their captors. In all ants, the feeding of the young seems to be the first work to which newly matured workers devote themselves, and it is certainly the most suitable employment for them until their skins are sufficiently hardened to make them fit to go out on foraging expeditions, when they may have to fight for their own lives or for those of their brethren. The practice of keeping slaves or assistants, of an inferior race, has not advanced in *F. sanguinea* to such an extent as it has in some foreign species, where the captors are entirely dependent, even in the act of feeding, upon the exertions of the slaves. The red ant can apparently manage as well without slaves as with them; moreover, it does not seem to be particular about the species to which its helpers belong. Mr. F. Smith, of the British Museum, used to say that he had found the workers of four other kinds in the nests of this slave owner.

The origin of slave holding is obscure, but it seems likely that it may have arisen from the capture of pupæ of other species in time of scarcity, to be used as food. Ants in general are quite prepared to use the pupæ of other species for this purpose, and if, on occasions of scarcity, other nests were plundered and more pupæ carried off than were required for immediate consumption, the residue would probably mature in the nest of their captors, and might then begin to take on themselves the nursing function, to the manifest advantage of the other party, who might thus be induced to bring in more for the same purpose. Summarizing what has been said above, we have shown that a smaller and weaker species of ant may be associated in the same nest with a larger and more powerful one in any of three ways—as a mere companion or lodger, or even, perhaps, pet, as a parasite, and as a slave or auxiliary.

The nature of the nest, and, in consequence, the employment of the workers in constructing it, varies with the species. Some, such as the wood ant and the *Formica exsecta* referred to above, construct great mounds composed of bits of stick, pine needles, bents of grass, fragments of fern fronds, etc. These fragments are not in any way fastened together, but simply placed carefully one upon another, in such a way as to form a fairly compact mass, which is firm enough to resist a good deal of pressure. A large mound, of say two feet high and ten or twelve feet in circumference, must contain many thousands of twigs, and when the number and the careful disposition of these is realized, one can form some notion of the vast amount of labor that its construction represents, all of which falls to the share of the workers. For the collection of the materials, the ground for large distances round the nest is traversed again and again, the army of collectors following certain definite tracks, which, by the trampling of innumerable little feet, in time become distinctly marked roads, and from which, in order to improve them, any obstacles that are not too large nor too firmly fixed are intentionally removed. A suitable fragment having been discovered by any member of the collecting party, the little creature seizes its prize with its jaws in such a way as least to incommode its own movements on its return journey, keeping it, if possible, pointing forward and raised well off the ground. On arriving at the nest, it places its load in position, and in doing so a good deal of judgment and discretion must be exercised, for the pile is not simply to be an indiscriminate heap, but is to be traversed through and through with tunnels and passages, large enough to allow free passage to and fro for the inhabitants, and regular enough to allow of pupæ being laid out along them; and openings must be left at different spots on the sides of the mound to serve as entrances to the nest. These also must be so arranged that they can be closed at night by putting up barricades of interlacing fragments, a duty which devolves on sentinel workers. It is nothing short of marvelous that so many hundreds and even thousands of individuals should be able to act in concert, and contribute piece by piece to the raising of so deftly and securely constructed an edifice, without any single presiding genius to lay the plans and see to their execution, and it seems to point to a remarkable degree of intelligence and power of adaptation on the part of the workers, such as to enable them to fit in and utilize to the best advantage fragments of all sorts, sizes, and shapes. It is also a remarkable fact that the symmetry of the nest is always well preserved; its outline is regular, and the slope even on all sides, although the builders, in consequence of their small size as compared with the nest, and their position on its surface when in the act of building, cannot possibly see more than a very small portion of its outline as they deposit and arrange their load.

The above-ground structure just described is not the whole of the nest; there will be tunnels below ground as well, underneath the dome, and the earth from these has to be removed, fragment by fragment, by the jaws of the workers, and carried up above. The growth of the nest, in both its divisions, must, of course, keep pace with the increase of population, which involves ceaseless labors on the part of the architects and builders; while damage to the structure, caused by such accidents as the fall of objects upon it, will call forth the energy and skill of the engineers of the community to effect a speedy repair of the breach. We have thus seen that, in the case of such a species as the wood ant, the collection of materials for the construction of the nest involves long and frequent journeys, and no inconsiderable proportion of the time of the laborers must, therefore, be spent in this employment. As its popular name implies, this ant usually forms its nest in woods, preferring pine plantations, for here there will be abundant material strewed about the ground wherewith to form its conical piles. It is found all over the country. The slave-making ant, on the other hand, though in appearance very similar, prefers to excavate its gallaries in banks, or round the stumps of gorse, and is found chiefly in sandy localities in the southern counties, especially Surrey and Hampshire. *Formica exsecta*, the species referred to above as having such extensive colonies, forms mounds in which bits of fern fronds, ling, and grass are used. *F. congerens*, an insect very much like the wood ant, also makes mounds, and the Rev. Farren White mentions a large one he found on a sloping bank covered with fern, heather, and gorse, on the margins of a stream; it was about a foot high and over eighteen feet in circumference, and had seven entrances.

Our other ants do not form mounds of this sort, but chiefly excavate the soil, or the trunk of a tree. Some, like *F. cunicularia*, mine under stones, taking advantage of the protection thus afforded. The common *F. fusca*, one of the chief slaves of the red ant, delights in banks, especially such as face the south. The margins of the footpaths in our gardens often bear witness to the presence of the garden ant (*Lasius niger*), in the little heaps of grains of earth which the workers have laboriously brought out one by one from the soil beneath; this species will, however, sometimes excavate the stumps of trees. The black ant (*L. fuliginosus*) usually fixes on the bottom of an old post or the decaying stump of a tree for its abode; it excavates the wood in galleries, the walls of which always become stained black in consequence of its presence. The abodes of the common yellow ant (*L. flavus*) are the rounded grassy mounds, generally something under a foot in height, which are so familiar in meadows and heathy places. In this instance the dome is composed of earth, and though this, as well as the ground beneath, is excavated through and through with tunnels, the growth of the turfy grass is not interfered with, and hence great firmness and compactness is imparted to the nest. As the colony multiplies, the dome increases in size by the transference to the outside of the particles obtained from the excavations of the interior, in such a way as to distribute it uniformly and not destroy the symmetry of shape. As the deposits are gradual, grain by grain, they do not prevent the continued growth of the grass, which is ever extending itself outward, forming an excellent thatch and acting as an efficient watershed in case of rain. The insect can, however, adapt itself to circumstances, and in hilly country where grassy mounds are impossible will avail itself of the protection afforded by loose fragments of rock.

The red stinging ants (*Myrmica*) similarly excavate the ground under stones, while a neat little reddish species called *Leptothoraæ acervorum* (Fig. 5) forms

FIG. 5.—Queen of *Leptothorax acervorum*, deprived of wings. A burrower under bark. Magnified eight diameters.

galleries under the bark of trees, especially fir stumps. Lastly may be mentioned a thin and wiry small black species, the workers of which have a squarish head which is streaked with longitudinal furrows; it is called *Tetramorium cæspitum* (Fig. 6), and is found at various places along our southeastern coasts, seeming for some reason or other to prefer to be near the sea. It also shams death when disturbed, folding up its legs

FIG. 6.—*Tetramorium cæspitum*. Worker. A sea coast ant. Magnified ten diameters.

and lying quite still. We have thus seen that the lives of the worker ants in all these latter species are spared much of the labor which falls to the lot of the mound builders, and whatever journeys are undertaken will be, not for the accumulation of building material, but only for obtaining food.

Ants feed chiefly upon insects of various kinds, honey, honey dew, and fruit, and for a large nest the daily bill of fare must be extremely varied and comprehensive. In nests of only moderate size, the number of individuals will run up to thousands, while of very large ones Sir John Lubbock's opinion is that "perhaps London and Pekin are about the only human cities which can compare with them" as to population. The amount of food that such multitudes would daily need is difficult to conceive, but so far, at least, as animal food is concerned, the requirements of a large nest would probably demand that many thousands of small insects of different kinds should be slaughtered every day. The hunting and gathering in of this quarry is largely left to individual enterprise, at least among the species found in this country, no organized foraging parties being usually employed; possibly, however, certain special individuals may be sometimes told off for the work. The corpse of a larger insect, such as a good sized beetle or a bumble bee, is an excellent find; if too large and heavy to be dragged to the nest in its entirety, even by the united efforts of a gang of laborers summoned by communications from the original discoverer of the booty, the carcass must be cut up where it lies and carried home piecemeal, an operation not difficult of accomplishment by insects that always carry in their mouths a good pair of scissors in the form of mandibles. The collection of honey dew leads many ants to climb trees and plants, and wander over their leaves in search of the deposit or of the aphides which produce it.—*Knowledge.*

[FROM THE RURAL NEW-YORKER.]

MAKING THE VINEYARD.

The Questions.

1. How do you prefer to propagate grapevines?
2. At what season do you make cuttings?
3. Of what length do you make them, and when and how do you plant them?
4. Do you prefer fall or spring planting for vineyards?
5. What kind of trellis do you prefer?

THE WHOLE STORY WELL TOLD.

1. I prefer grapevines grown from mature or ripe wood, the cutting being six to ten inches in length, according to the length of the joints, including not less than three eyes, in preference to those grown in layer-grown soft wood, one or two eyed cuttings or grafts, because I get stronger, more symmetrical plants, with both deep anchor roots and feeders above ground. In this climate (Grayson County, Tex.) a vine with only the surface feeders, such as most Labrusca varieties make, is feeble and short-lived.

In the picture, Fig. 1, *1*, *2*, *3* and *4* indicate about the

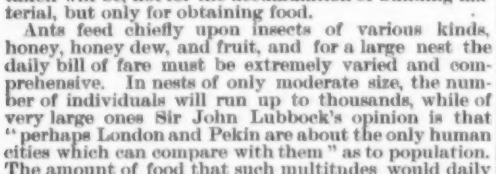


FIG. 1.—MUNSON'S METHOD FOR GRAPE CUTTINGS.

1. Four-eye cutting of mature wood. 2. One-eye cutting of mature wood. 3. Green-wood slip, started with "bottom heat." 4. Layer plants—to be cut apart at A, B, C, D.

comparative character and relative strength of plants grown from, *1*, a four-eye cutting of mature wood; *2*, a one-eye cutting of mature wood; *3*, a green-wood slip, started with "bottom heat," and, *4*, layer plants, to be cut apart at *a*, *b*, *c*, *d*. It is clear that plant *1*, with its anchor roots, has a decided advantage, especially in a hot, dry climate, over the others, with only small, shallow roots.

It is a well known fact that a vineyard set with strong, deeply rooted plants of any variety, when all other conditions are the same, stands a far better chance for profitable aftergrowth than one set out with small or stunted plants. Plants that are grown as in Fig. 1 (*1*) are, in my estimation, worth more than twice as much as those grown as in Fig. 1 (*2* and *4*); while those grown from soft wood, as in Fig. 1 (*3*), are scarcely worth the setting. I regard the layer plants, as in Fig. 1 (*4*), worth more than such as are seen at Fig. 1 (*2*)—single-eye plants—especially if the plants are set deep, say down to the third or fourth eye on the shoot, when put in the vineyard. The French consider no plants good unless grown from very long cuttings, say 12 to 16 inches.

The distinction between feeding and anchor roots is an important one, on which the manner of propagation has an essential bearing; for in the growing season the feeding roots work throughout the surface soil, consuming about all the assimilable grape food, and when the ground is plowed or spaded over, and fertilizers are worked in, the feeding roots are greatly mangled and injured, and if the vines have no anchor roots they suffer greatly both from disturbance and in severe droughts.

The most successful vineyardists in hot climates, each year at pruning time, trim away all the last year's feeding roots, as well as superfluous bearing wood. Then the surface soil should be thoroughly pulverized several inches and fertilizers be mixed in, so that each year the ground affords a fresh pasturage for the young, thrifty roots that start from above the anchor roots. If the subsoil isn't good and isn't porous, with good drainage, trenches should be dug two feet or more deep, with slopes, to drain off the excess of water, and the bottoms should be filled with bones, rotting brush or logs, to serve as a permanent source of food for the anchor roots.

Fig. 2 will help to make my ideas comprehensible. A

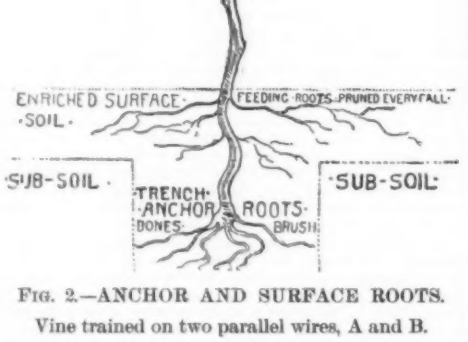


FIG. 2.—ANCHOR AND SURFACE ROOTS.

Vine trained on two parallel wires, A and B.

vineyard planted in this way, with plants grown from long cuttings, will, with care, last indefinitely and bear heavy crops every year.

2. I prefer to make cuttings within one to three weeks after the leaves have fallen, before the wood has lost any vitality by hard freezing. Any temperature about zero, or below, consumes to a large extent the vitality of even the hardiest species and varieties.

3. This question is mostly answered under Fig. 1 (*1*). Fig. 3 completes the answer. After they have been put up in bunches in the fall, the cuttings are buried in loamy, well-drained soil till corn-planting time, in spring, when they are "lined out" with a dibble, as shown at Fig. 3.

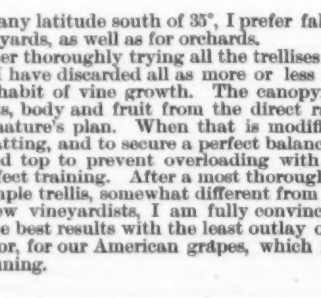


FIG. 3.—THE PLANTING OF CUTTINGS.

4. In any latitude south of 35°, I prefer fall planting for vineyards, as well as for orchards.

5. After thoroughly trying all the trellises commonly in use, I have discarded all as more or less unnatural to the habit of vine growth. The canopy, to shade the roots, body and fruit from the direct rays of the sun, is nature's plan. When that is modified to prevent matting, and to secure a perfect balance between root and top to prevent overloading with fruit, one has perfect training. After a most thorough test of a very simple trellis, somewhat different from that used by a few vineyardists, I am fully convinced that it gives the best results with the least outlay of material and labor, for our American grapes, which need long-arm pruning.

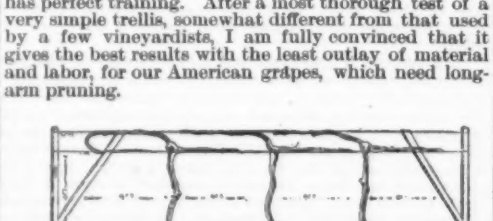


FIG. 4.—MUNSON'S SYSTEM FOR TRAINING THE VINE.

The above engraving is inaccurate as showing Mr. Munson's system. The reader, however, will see wherein it is faulty by the explanation given in the first paragraph of the next column. The brace and posts at each end should be two swinging posts of the same length.

This system consists of two posts seven feet long, set two feet deep in the same hole, with tops flaring apart two feet; a pair being set at each end of each row and midway between every third and fourth vine, thus leaving three vines eight feet apart, as I plant common kinds between each pair of posts. A No. 11 galvanized wire is stapled on the tops of the posts, making two strands stretching along each row, in a parallel way two feet apart at the same height from the ground—five feet, as shown inaccurately in Fig. 4.

The vines are shown as pruned with two arms and tied, at the end of the second year. As the vines get stronger, more arms, even up to four for each vine (one four feet long for each wire), or two of greater length (say up to eight feet each), trained S fashion from wire to wire, to suit the trainer's fancy, or the amount of bearing wood possessed and capable of being utilized to advantage by the vine. Looking down upon the trellis when the vine is pruned and tied, it might present the various aspects shown at Fig. 5.

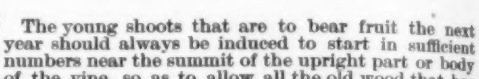


FIG. 5.—TRAINING VINES ON THE TRELLIS.

W, W are wires, and A, B, C, vines.

The young shoots that are to bear fruit the next year should always be induced to start in sufficient numbers near the summit of the upright part or body of the vine, so as to allow all the old wood that has borne to be cut away back to the new shoots. Remembering always that American grapes bear better on the long arms than on the short, one to three eye spurs, the rule should be a few strong long arms, and not many short, weak spurs, as the old systems induced.

This system of training has among others the following advantages: 1. It keeps the sun from baking the roots, bodies and fruit. 2. It costs little in material and labor to prune and train the vines. 3. It affords free ventilation below the fruit, leaving it hanging *free* in the most convenient position for spraying and harvesting, while it is out of the way of domestic fowls, and can be easily sacked. 4. Cultivation is most easily accomplished. 5. One can pass easily from row to row. 6. It maintains the equilibrium and life of the vine to the fullest extent, and secures all fruit possible from a given area. 7. Pruning and training are reduced to the simplest possible condition, so that a novice can readily do satisfactory work after a few vines have been pruned and tied before him.

T. V. MUNSON.

THE TWO-TRELLIS: THE "TWO-ARM" SYSTEM.

1. By cuttings. 2. In the fall. After the leaves have fallen, I cut the cuttings in lengths—say, 16 to 20 inches—tie them in bunches, and pack them in moist sand in the cellar till they are wanted for use in the spring. 3. They should be six or eight inches long, with two or three buds. Cut quite close to the lower bud, and leave about an inch of wood above the upper bud. As soon as the ground is in good working condition in the spring, having been previously prepared and cleared of stones, I make trenches or furrows about eight inches deep, place the cuttings in them in a sloping position about four inches apart, in rows one foot apart, so that the top buds will be just below or at the surface when leveled; firm the soil and draw some over the top buds; sawdust is best for this. Keep the soil moist with mulch or water till the cuttings are well started, and allow no weeds to grow. Plant in vineyard the next spring as early as the ground is ready, in rows nine feet apart, and ten feet apart in the rows. 4. Spring, although my experience here in Dutchess County, N. Y., does not include fall planting. 5. The two-wire trellis, and the "two-arm" system of trimming. This system has been steadily growing in favor here for several years past, and wherever it has been adopted instead of the "four-arm" or Kniffin plan, it has proved advantageous, without a single exception to my knowledge, and, especially since spraying has become a necessity, the greater convenience of doing the work under this system has been so manifest as to induce a large proportion of our growers to adopt it. In it two arms are left for the top wire, each having ten or twelve buds, and being about four feet long, extending along the top wire. It has been found beneficial to wind the arm around the wire two or three times, which checks the downward flow of sap and aids fruit development. The arms should not be so long as to touch those of adjoining vines, as this would cause a mass of tangled growth at that point, unless the buds or shoots were pruned away. A space of a foot is not too much to leave between the tips of the arms. One or both of these arms may be brought down to the lower wire, as shown at Fig. 5; but this would detract from the convenience in spraying, with no corresponding advantages of an increased yield even of an inferior quality of grapes. Let me say here that a theoretical objection to this system advanced by some, viz., that after a few years the vine would become worthless, for the reason that the arm left for fruiting would necessarily be further removed from the main vine each year, has no foundation in practice, as new shoots are produced near to or out of the main vine, sufficient for this purpose. But a greater consideration than convenience in spraying is the fact, amply demonstrated, that better grapes are produced, with less work in trimming and tying, by this system than by the "four-arm" plan.

WARD D. GUNN.

FROM A HUDSON RIVER GROWER.

1. Where a large vineyard is to be set, I believe it is far cheaper for the average grape grower to purchase his vines from some one of the many reliable nurserymen than to propagate them. I have always done so. But when I have in my trial rows a variety of which I would like to have more specimens, and the nurserymen's price is high, I increase by layering or by cuttings. As the latter method requires less time and attention to secure the same number of vines, I prefer it, although ordinarily a few stronger ones may be obtained by layering.

2. Cuttings may be taken at any time during the late fall or winter months—preferably just before the ground has frozen hard in November or December.

2. Without allowing the wood to dry, after it has been pruned from the vine, it should be cut in lengths of from seven to ten inches. This will leave two or three buds on each cutting. Just below the lower bud the cut should be made square across, and at the upper end it should be made an inch or two above the top bud. By this means it is easy to tell which is the upper end of each cutting. For a small quantity the cuttings may be tied in bundles, placed in a box (an empty raisin box is suitable) and buried; in doing this a dry place should always be chosen; the north side of a fence or building is preferable, as the swelling of the buds in spring will be there retarded. Put dirt enough over the box to make a small mound, to shed off water. It should not be disturbed until the buds on growing vines have swollen as large as peas. By this time the ground will have settled, and be in good condition for working. A rich, mellow piece of soil, free from stones, is best. This should be plowed or spaded deep and made as fine and mellow as possible. The cuttings should be placed in a straight row, with the top buds even with the surface of the ground, and the earth be pressed very firmly around them. The best way I have found to do this is to lay a board on the ground, so that one edge will be a guide for making the row. With a spade throw out a narrow V-shaped trench. The box containing the cuttings is then taken from the place where it was buried, and its contents are emptied on the bed near the board. It will be found that the buds on the cuttings have grown larger than on growing vines in the open air. In handling the cuttings be careful not to loosen or break off any of the buds. Place each cutting in an upright position in the trench, close to the edge of the board. If care be taken the row will be perfectly straight, and the top bud of each cutting will be even with the surface of the ground when the trench is filled. Haul in the loose earth, so as to fill the trench and tramp it hard, taking great care not to disturb the top bud on any cutting. Then carefully fill the trench, so as to nearly cover each bud; the inch or two of wood left above the top bud on each cutting will mark the row. The surface of the ground should be kept clean and mellow during the season. Until each bud has made a growth of two or three inches, great care is needed in hoeing and weeding, lest the upper bud should be broken loose, which would destroy that cutting. If well ripened, healthy wood has been used, every cutting should not only live, but make a growth of two or three feet.

4. Here in Orange County, New York, I prefer spring planting.

5. This depends on circumstances. If grapes are to be grown for market, on hilly land like most of that in the Hudson River Valley, two wires at the heights of 3 and 5½ feet make the best and cheapest trellis. If on level ground, where a vineyard may be cultivated both ways, the arbor style, made by spiking cross bars, to support three wires, on the top of posts set about 20 feet apart, 6½ or 7 feet from the ground, has many advantages, and some disadvantages, while for family use only, any style of trellis that suits the owner's fancy is admissible. W. D. B.

GEO. W. CAMPBELL'S CHOICE.

1. Personally, here in Delaware County, O., I prefer to propagate grapevines from single eyes, and grow them in cold greenhouses the first season. For my own use I prefer vines so grown to any others. The objection to this mode is the expense. It does not pay to grow any except the new and high-priced varieties in this way. 2. I have cuttings, both for out-of-doors and under-glass planting, made in autumn; soon after the fall of the leaves and perfect maturity of the wood. 3. For single-eye cuttings, one and a half to two inches, planted in sand beds with artificial bottom heat, early in April. For open-air planting, nine to ten inches in length, with two or three eyes, the bottom cut just below the lower bud. These are planted in spring as early as the ground can be put in good condition. 4. Fall planting for the South, or wherever the winters are mild; spring planting for Northern or cold regions. 5. My choice has always been a wire trellis of three wires, galvanized, height from 4½ to 5 feet.

GEO. W. CAMPBELL.

FROM A VETERAN EXPERT.

1. By cuttings, if many plants are needed, or by layers, if only for a plant or two. For rare or very costly varieties, by single eyes, with bottom heat. 2. Preferably in autumn, after the foliage has fallen. 3. I make the cuttings six to eight inches long, with not less than two eyes apiece. Here, in Van Buren County, Mich., I plant them in spring, after they have been calloused by being buried through the winter and early spring, with the butts upward, in a warm exposure. We open a trench east and west; slope the north side facing the midday sun, lay the cuttings against the slope, with the upper buds at the surface, cover with an inch of earth, partially fill the trench with well-rotted manure. If the weather is too dry, we cover to the level of the surface with earth. 4. Preferably early spring, in mild seasons early fall. 5. Where laying down and covering are necessary, I prefer an upright trellis with three wires; in climates where laying down is unnecessary, a horizontal trellis with four wires will answer best.

T. T. LYON.

1. I prefer to propagate vines from cuttings in case of such varieties as will grow in this way, otherwise by layering. 2. From November to February. 3. From two to three eyes, according to the distance between them—generally about 10 inches. I plant the cuttings about April 1, or when the ground is in tillable condition. I prepare the ground and work it to the depth of 12 to 15 inches, and place the cuttings three or four inches apart in rows. 4. I prefer April to any other time for planting, as everything is then in the best condition here, in Jefferson County, Ky. 5. A three-wire trellis, with posts 24 feet apart, or to every three vines, set straight in the row, with good heavy wire. No. 11 galvanized steel preferably. GEO. R. WOOD.

EVERY year a layer of the entire sea fourteen feet thick is taken up into the clouds. The winds bear their burden in to the land and the water comes down in rain upon the fields to flow back through rivers.

EARLY'S CURLED SPROUT.

IN the absence of color, we are not sure whether some enthusiastic florist might not think our illustration was intended to represent an eccentric hollyhock! It is not so, however; what it does show is a very promising new form of sprouts raised by Mr. W. Early between the Brussels sprouts and the curled kale. Judging from the specimens sent to us, the new comer has some excellent qualities. Its good looks well commend it to the exhibitor, its firm substance to the cook, its flavor to the consumer. In addition, Mr. Early tells us that it is perfectly hardy, and the specimens he sent us recently quite bore out that statement.—*The Gardeners' Chronicle.*

SOAP PLANTS.

By JOHN R. JACKSON.

PROBABLY at no period of history has soap been brought so prominently before the civilized world as at the present. The article is a compound substance, and the reputation of rival soap makers is due probably as much to the persistent manner in which they keep their special products before the notice of the public as to any particular ingredient used in their composition. Practically, soap may be said to be a vegetable product, for indirectly vegetable substances, especially oils, enter into its manufacture; but, besides these, there are numerous plants that possess a direct saponaceous principle. Many of these are well known, but we do not remember that anything has been done—at least in recent times—in this country to collate matter bearing on these interesting and in many cases useful plants, a more extended knowledge of which might lead to many of them becoming of some practical utility. It is true that, in 1875, Professor Bernardin, the late able conservateur of the museum at Melle, near Ghent, published a little pamphlet, entitled

EARLY'S HARDY CURLED SPROUT.

"Classification de 40 Savons Vegetaux:" but as the circulation of this contribution to the subject is necessarily limited, a few general notes on saponaceous plants will probably have some interest. These notes have been arranged in botanical sequence, as probably the most useful to all concerned.

Leontice Leontopetalon, L.—A herbaceous plant belonging to the natural order Berberideæ, growing about a foot high, native of Asia Minor, frequent in Greece and all the islands of the Archipelago. Little seems to be known as to the actual detergent properties of the plant, except that the root is stated to be used at Aleppo as a substitute for soap.

Monnina Polystachya, R. and P., and M. Salicifolia, R. and P.—Plants belonging to the milkwort family—Polygalleæ—known as "yalhoi" in Peru; and of them Lindley says: "The bark of the roots, when fresh, is pounded and moulded into balls for use in washing. The dry bark also is detergent, and readily froths when agitated in water. It is used by the Peruvians as a substitute for soap, and the ladies of Peru ascribe the beauty of their hair to the use of an infusion of this bark. The silversmiths of Huanuco employ it also for cleansing and polishing wrought silver."

Saponaria Officinalis, L.—This well-known plant belongs to the natural order Caryophylleæ, and is generally known as the "soapwort," or "fuller's herb." Though found in hedges, on roadsides and in fields, chiefly in the southwest of England and North Wales, it is considered only a naturalized plant in Britain. It is distributed through Europe and West Asia, and has been introduced into the United states. The leaves, when boiled or bruised in water, become saponaceous, and were used in olden times as a substitute for soap, especially, it is said, by the mendicant friars. The lather so formed has all the effects of ordinary soap, readily removing grease; and in consequence of its not being affected by acids, it has been suggested that it might be usefully applied where soft water is not obtainable.

Gypsophila Struthium, L.—This is generally known under the name of "Egyptian soap root." It is a native of Spain, where it is said to be used instead of soap for scouring. The root of G. paniculata, L., is used in Lycia for a similar purpose, and it is also extensively sold in the bazars of Western Afghanistan and Northeastern Persia as a soap for washing clothes. The powdered roots of this species, mixed with honey, are used as food by the people in Lycia. Dr. Fluckiger has recently shown that G. arrostii, Guasone, yields Sicilian soap root, samples of which have been collected in Catania. The following species of Gypsophila are also included in Professor Bernardin's list as producing saponaceous roots: G. acutifolia, Fisch., Eastern Europe and Siberia; G. altissima, L., Siberia; and G. fastigiata, L., described as the "saponaire" of Spain; and, besides these, the following plants belonging to the same natural order: Lychnis chalcedonica, L., known in France and Portugal as the "Croix de Malthe" in Italy, as the "Croce de Cavaliere," and in Spain as the "Croix de Jerusalem." It is stated to be used as soap in Tartary. Lychnis dioica, L., native of the South of Europe, is used at Pesth for washing; and L. sylvestris, Schkr., also a European species, is similarly used, as well as Agrostemma githago, L., which is now sunk under lychnis; and Silene inflata, Sm. Little, however, seems to be known about the extent to which these last named plants are used.

Acanthophyllum Macrodon, Edgew.—This is a very spiny, tufted, herbaceous plant belonging to the same order—Caryophylleæ—found in India and Afghanistan.

The root stock, under the name of "bekh" (a name which is also applied in Afghanistan to Gypsophila paniculata), is used as a soap substitute for washing clothes, woolens, etc., and is sold in all the bazars of the larger villages.

Sida Lanceolata, Retz.—It is stated that this malvaceous plant is known as the "broom plant" in Brazil, and that a soap is made of the ashes.

Adansonia Digitata, L.—This is the well-known "baobab" of West Tropical Africa, and belongs to the tribe Bombaceæ, of the natural order Malvaceæ. The ashes of the fruit are boiled with rancid palm oil, and are said to form an excellent soap, in Africa.

Balanites Ægyptiaca, Delile.—This plant, which is a shrub or small tree, is known as "soump" in Senegal, and belongs to the natural order Simarubeæ. The young fruits are purgative, and when ripe are edible and formed into an intoxicating drink by the negroes of the West Coast of Africa. Bernardin says the roots are saponaceous.

Æsculus Pavia, L.—The American horse chestnut, or buck-eye. The roots of this tree are said to be preferred even to soap in some parts of America for washing and whitening woolens, blankets, and dyed cottons, the colors of which are improved by the process. Satins washed in this manner, and carefully ironed, look almost as well as new.

Sapindus Saponaria, L.—A slender tree, native of the West Indies and Tropical America. It bears a fruit about the size of a gooseberry, composed of a thick, tough, almost horny rind, covering a hard, globose black seed. The outer covering of the fruit, if allowed to stand in water for some little time, swells and produces a lather. Browne says: "The seed vessels of this plant are very detersive and acrid; they lather freely in water, and are frequently used instead of soap, for a few of them will cleanse more linen than sixty times their weight of that composition, but they are rather too sharp, and observed to corrode or burn linen in time, and the water in which the tops or leaves have been steeped or boiled is observed to have the same quality in some degree."

S. Mukorossi, Gærtn.—This species is known as the "soap nut tree" of North India. It is a handsome deciduous tree, cultivated throughout Northwest India, Bengal, Kumaon, Sylhet and Assam. The fruit, which is somewhat similar to that of the last named species, but considerably larger, is very much used in India as a substitute for soap, for which purpose it is also exported. It is chiefly used for washing silk and woolen cloth, being regarded as superior soap by native manufacturers.

S. Trifoliatus, L.—A large tree of Bengal, South India, and Ceylon, and often cultivated. It is known as the "soap nut tree" of South India, and its seed vessels are used for a similar purpose to the last named species.

Colubrina Asiatica, Brongn.—A large shrub or small tree of Tropical Asia, Queensland, Northern Australia and extending into the Pacific Islands. It belongs to the natural order Rhamneæ. Seemann says that the Fijians use the leaves in the preparation of a hair wash to destroy vermin.

Vitis Saponaria, Seem.—A climbing plant belonging to the natural order Ampelideæ, and found in Queensland, as well as in the Fiji Islands, where, Seemann says, the natives use it for the same purposes as the last. The stem, especially the thicker part, is cut into pieces from a foot to eighteen inches long, heated on hot stones, and, when thus rendered quite soft, it produces in water a rich lather, almost equal to that of soap.

Gymnocladus Chinensis, Baill.—This leguminous tree is a native of China, as its specific name indicates. It is thus described in Forbes and Hemsley's "Index Floræ Sinenis:" "This is the soap tree, the fei-tsao-tou, or fat black bean, of the Chinese, used by women in washing their heads and hair." The pods, which are about three inches long, one and a half inch wide, and one inch thick, are beaten with a mallet, and placed in water for about two days. They are sold in the market at the rate of about sixteen to twenty a penny. Bernardin says that the bark of the branches of the allied species, G. canadensis, L., is used in Canada as soap.

Gleditischias Sinenis, Lam.—This is also a Chinese leguminous plant, the pod of which, when dry, is quite black, about ten inches long, one and a half inch wide, and very thin. It is used by the Chinese as soap, and also to restore animation in partially drowned persons.

Entada Scandens, Benth.—A large, woody, leguminous climber, found in the tropics generally. The spirally twisted stems are soft, fibrous, and spongy, and would appear to contain saponaceous matter, for the ladies of Manila use them, under the name of "gogo," for washing the hair. The kernels of the seeds are used in Nepal for the same purpose, and in Bengal the hard seeds are employed by washermen for crimping linen.

Tetrapleura Thonningii, Benth.—A large leguminous tree of West Tropical Africa. The pods, which are from six to ten inches long and about one and a half inch broad, are rounded at the apex, and each valve has a stiff longitudinal, often wavy, wing running down its middle from end to end. They are of a shiny brown

color when dry. These fruits or pods contain a saponaceous principle, and are sold in the Sierra Leone markets for washing purposes. They are also occasionally imported into this country. The plant is known as the "ogagouma" in Gaboon.

Acacia Concinna, D. C.—A climbing leguminous plant, native of the Eastern Himalayas, western and eastern peninsulas of India, Ceylon, Malay Islands and China. The pods vary in length from four to six inches, are about three-quarters of an inch wide and one-quarter of an inch thick. They are constricted between the seeds, and, when dry, are of a brown color and have a shriveled appearance. A considerable trade is carried on with them in some parts of India, as they are much used for washing, especially for the head.

Bernardin says that the pods of Acacia latronum, Willd., a small Indian tree, are used for the same purposes.

Albizzia Lophantha, Benth.—A tall shrub or small tree of West Australia; is described as containing 10 per cent. of saponin in the dried roots; while A. lebbek, Bth., a tall tree, widely distributed through India, Burmah, Ceylon, Malay Islands, China, North Australia, and Tropical Africa, is said by Bernardin to contain a saponaceous principle in its leaves, in consequence of which they are used in India and Arabia for washing purposes.

Enterolobium Timbouva, Lam. = E. Cyclocarpum, Griseb.—A lofty leguminous tree of Jamaica and Venezuela. The pod is nearly circular, the stalk being apparently situated in the center of the circle, and the positions of the seeds are marked by regular depressions. These pods are known under the name of "orejera," and are used for washing in New Grenada.

Quillaia Saponaria, Mol.—A tree some fifty to sixty feet high, native of the Chilean forests, and belonging to the natural order Rosaceæ. The tree is known as the "quillai" or "cullay" tree, and the bark as quillaia, or soap bark. It is rough and dark-colored externally, while the inner bark is of whitish gray color. It is very rich in saponin, and it is said to contain a large quantity of carbonate of lime and other mineral matter. It is commonly used in Chile for washing clothes and in France for washing silks, as it is said to remove dirt and grease and to impart a luster without injuring the color. It may also be used for cleansing hair brushes, and for similar purposes, under conditions in which soap and other alkalies are powerless. Besides this, the pulverized bark makes an excellent hair wash, and is said to be largely used by French hair dressers. By placing some of the powder in water and stirring it, it readily produces a froth, and in consequence of this, is said to have been used to give a fictitious head to stale beer. Quillaia sellowiana, a Brazilian species, is described as having similar properties.

A species of *Begonia*, known in Egypt as the "achaloax," furnishes a bark, a decoction of which, according to Bernardin, is used in sheep washing.

The leaves of the well-known papaw (*Carica papaya, L.*) also contain saponin, and are used by the natives in tropical countries for washing clothes.

Jacquinia Armillaris, Jacq.—A low, rigid tree belonging to the natural order Myrsineæ, and found in the West Indies, Brazil and Florida; has saponaceous leaves, which are sometimes used as a substitute for soap.

Pircunia Saponacea, Welwitsch, known in Angola as "mutonga-tonga."—The roots are said to be saponaceous. The genus is now referred to Phytolacca.

Among monocotyledonous plants there are several that have saponaceous properties. Thus, in the order Scitaminea, the fruit of Bromelia pinguin, L., is reported as having been found useful as a soap substitute. A kind of vegetable soap is stated to have been prepared in Jamaica some years ago from the leaves of the American aloe (Agave Americana, L.), which was found as detergent as Castile soap for washing linen, and had the superior quality of mixing and forming a lather with salt water as well as fresh. In Peru the leaves of this plant are used by first wetting the clothes, and then beating them with a leaf of the agave which has been crushed; a thick white froth is produced, and after rinsing, the clothes are quite clean.

Chlorogalum Pomeridianum.—A liliaceous plant of California, forming a large oblong bulb covered with coarse brown fiber. It is known in California as the "amole." The bulbous root rubbed in water makes a thick lather, and is said to have a similar smell to brown soap. It was very much used by the North American Indians before the American possession of the country, and at the present time it is also much in demand for washing clothes, by merely removing the outer husk and rubbing the bulb over the fabric in the same way as soap.

Yucca Filamentosa, L., and several other species of yucca, natives of Carolina and Virginia, are described as yielding a saponaceous matter from their roots.

From the foregoing list of plants it will be seen how varied are the species in their botanical affinity, so that the saponaceous principle, though characteristic in some natural families, is very widely diffused.—*Chemist and Druggist.*

METEOROLOGICAL CHANGES IN FRANCE.

MONS. FLAMMARION, the French astronomer, has recently been directing attention to the climatic changes in France. According to the United States consul at Bordeaux, he states that, from actual figures obtained within the past six years, the temperature of Europe has been falling. France has been suffering for a long time from an excess of cold weather, the thermometrical readings at Paris having been one degree Centigrade below the normal heights. Other readings show even less favorable results. The fall is more noticeable in the spring than during other periods of the year. Similar phenomena are recorded in Great Britain, Belgium, Spain, Italy, Austria, and Germany, while the really cold countries, such as Denmark, Norway, Sweden, and Russia, have enjoyed, during the last four years, a temperature slightly above the average. In the days of Philippe Auguste.iin the 13th century, the wines of Etampes and Beauvais were the favorite beverages at court. Henry IV., a pronounced *bon vivant*, frequently expressed his fondness for the product of the Suresnes grape. At the present day, there is not a vineyard of importance north of Paris, and as for the *petit vin* now made at Suresnes, it has become only the drink of the poorer classes. In the middle of the 16th century, Macon was celebrated for its muscat wines, whereas the muscatel grape, at this moment, can scarcely be made to thrive there. Ancient chronicles mention the cultivation of the vine in Northern Brittany, where now even apples are not plentiful. Again, it is to be remarked that trees which once flourished in the north of France are at present found only in the extreme south, and a considerable number have disappeared altogether. Languedoc no longer grows the lemon, there is not an orange left in Roussillon. The Lombardy poplar, so familiar and picturesque an object in old French line engravings, is now nowhere to be found on French soil. These are facts which, says Consul Knowles, putting statistics out of the question, serve to illustrate the changes wrought by temperature in the great fruit-producing country of France.

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